ED WELL!

# OBSERVATION LESSONS ON PLANT LIFE

Newmann & Co. London.

A Wreath of Periwinkle


1 Periwinkle bud, 2 profile of half-blown flower 3 profile of full blown flower
4 Ring of full blown flowers on wreath of stems in centre of pattern.
5 Ripe seed vessels split open and twisted. The seeds show inside some of them. The leaves grow on the concealed stems in pairs.

# OBSERVATION LESSONS

ON

# PLANT LIFE.

## A GUIDE TO THE TEACHER.

*A Two Years' Course of Nature Study.*

BY

MRS. BEVERLEY USSHER AND DOROTHY JEBB.

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*Illustrated by Blackboard Sketches and by Floral Designs. The latter to serve as hints for the treatment of Plant Forms in conventional Art.*

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1903.

# In Memory of Arthur Gamul Jebb.

*Little Brother, sunny nature-lover, you left us years ago; since then we have missed you in the fields, and the woods are more silent than they used to be. But we have found comfort in these humble studies, and should they help others to love the country as we loved it, then shall we have fitly dedicated them to your bright spirit.*

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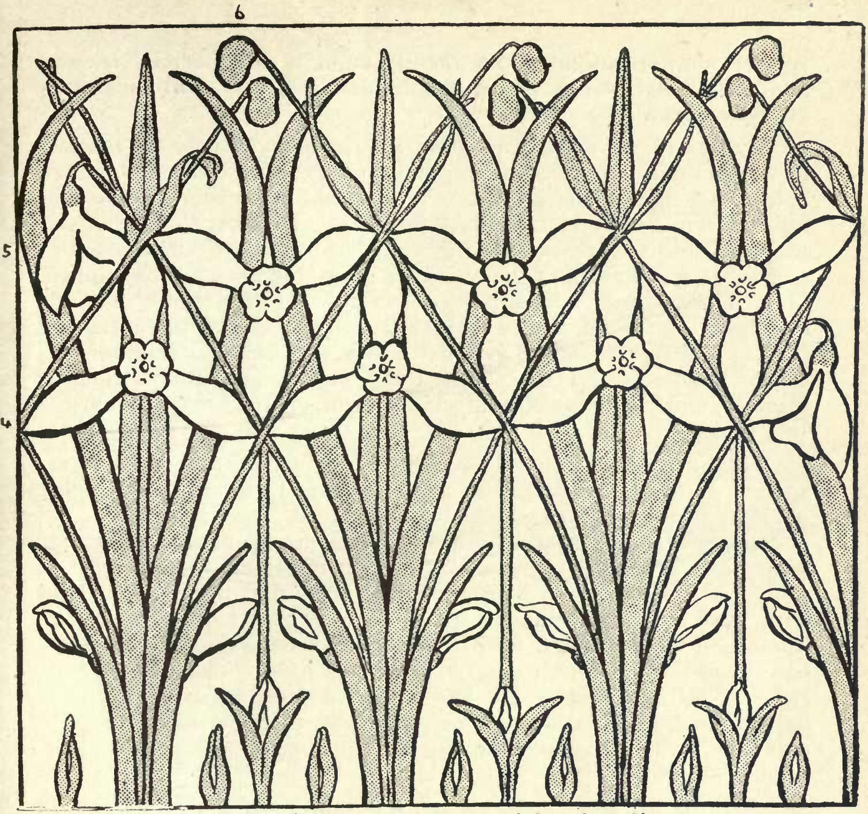
A Procession of Snowdrops




1 1 2 1 3 3 stages of Snowdrop Shoots
Snowdrop blossoms tilted face forwards & drooping profile 6 seeds and old sheaths

## PREFACE.

The following lessons are addressed in an informal manner—now to the teacher and now to the pupil. The reasons for such irregular style are as follow:—Playful phraseology is out of place in a teacher's book; but as his mere tool we feared this work would dismally fail to interest even himself. On the other hand, to address the pupils only and never the teacher would have meant producing a reader, and setting the children to think about commas and full stops and the meaning of words, when they ought to be asking questions and making discoveries concerning actual objects under observation.

Bailey, in his "Lessons on Plants" for American school children, is the only author, so far as we are aware, who as yet has written on our own lines; but his book not only deals with some unfamiliar plants, but it presupposes much greater intelligence than is ordinarily evinced by English country children. His questions sound, even to grown-up ears, like a series of riddles;

yet the answers might occur readily enough to specially trained minds. This fact has rather frightened us away from the interrogative form.

Certainly we *do* ask questions, but we leave it to the teacher to weave many more out of our running text according to his own ability and that of his pupils. We do not wish him to dole out information, but to set the class thinking. In order that he or she may be able to answer his questions, each child should *gather* and bring a specimen of the weed or vegetable about to be studied. Only in the case of such a large object as a cabbage should a single example be placed before the class. The special advantage of botany lies in the fact that illustrations are readily obtainable and easily handled. At the same time the fundamental notions it imparts, and the habit of analysis which it creates, may be carried into other subjects.

The attractive generalizations of modern science place observation *for its own sake* rather at a discount ; yet it is this spirit of loving observation which has produced the data of grand conclusions, and research must become more patient and less prejudiced if rapid progress is to be maintained. Therefore at school let us ask the young to *watch*, nor bribe nor satiate them with too much talk about great matters ; a small conclusion satisfies if it is coupled with a great deal of exploration, as we can testify who were brought up on pre-Darwinian Le Maont (Leçons elémentaires). He wrote for children when he had not half so much to tell them as we have now ; yet he made us love plant life, and for its sake and in its truth we unconsciously loved science as a whole.

In order to appeal to the eye more and to confuse the mind less, we have substituted art for rhetoric. Two hours a week are not too much to devote to a botanical object lesson if it is coupled with some form of art : (1) drawing, (2) brushwork, (3) designing, (4) paper cutting and folding.

**I. Outline Drawing.**

The Board of Education in its recent hints to teachers concerning object lessons recommends that children should draw the objects shown—the germination of seeds, the structure of flowers, etc. We recommend that the drawing should always be a mere note of main facts—the largest outline possible ; and it should always be made from nature, unless, for special reasons, a memory study is desirable. By the age of ten most of our children have copied things *ad nauseam ;* in any case they have learnt to handle their material, and the crude outline of a real thing should rather stimulate than baffle. (See example facing page 156.)

If the school is fortunate enough to be furnished with more than one blackboard, pupils may illustrate the lesson in rotation. They will then be able to draw from the shoulder uncramped by want of space. Otherwise they must make the best of their slates ; but both slate and blackboard had better be discarded in favour of

a large sheet of paper, where the outlines are intended as a guide to subsequent design. Excellent instructions abound already in the *Practical Teachers' Art Monthly* and elsewhere, so that it would be futile to go into much detail here concerning method. It is enough to say that until the pupil can see the object to be drawn with closed eyes he had better not set to work; once it is well visualized let him try to draw it immediately without raising his wrist from the task. (If the slate be made large enough to intervene between the child's eye and the object, he can stand up and take an occasional look at it and then draw it by successive acts of memory. Although accurate observation of detail is to some extent sacrificed, he is likely in this way to seize the shape of the whole better. This plan has been tried with great success.) Some teachers like the pupils to indicate the situation of leading lines by dots, but this is apt to interfere with the visualization of the object as a whole. The eye tends to travel from dot to dot mechanically, the hand following. In many leaves the ribs, not the outline, "lead" the eye most readily and should be drawn first. Accidental waves, rents, crumples and marginate minutiæ should be omitted. Rubbing out should be avoided; it is better to attempt the outline as a whole all over again. Charcoal is preferable to pencil work because it renders needless niggling impossible. But it is a mistake to give it to careless or troublesome children; they only break it, or allow their drawings to get rubbed or smudged.

**II.—Brushwork.**

It has been defined as drawing with a soft point instead of with a hard one. This definition will very often not apply to blobbing; a good plan is to fill colour into a *wet* faint brush outline. Grotesque shapes may in this way be avoided, more especially if, as recommended, the pupil has (at the previous lesson) familiarized himself with the outline in pencil or charcoal on separate paper. Marion Hudson has well expressed some principles of brushwork: *

"(*a*) That the teacher should not work from copies of any kind, but should discover suitable natural forms, and use them in his own way as the subject-matter for each lesson.

(*b*) Each lesson should be adapted to the capacities of the scholars, their power to appreciate form and colour, and their ability to represent these.†

(*c*) The object chosen for representation should be suited to the time of year.

(*d*) The Brushwork lesson should be connected as far as possible with the other lessons of the school, especially with the nature or object lesson."

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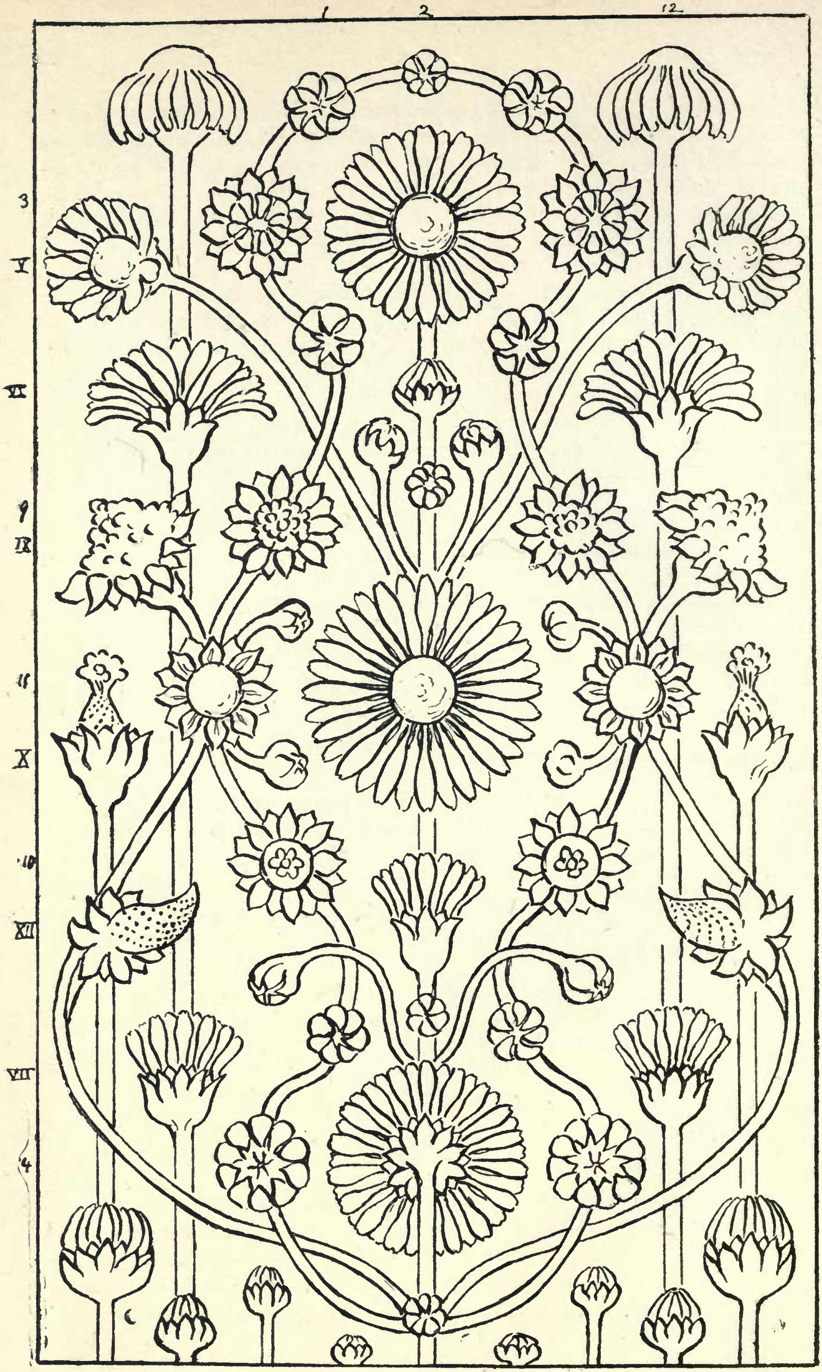
* "Elementary Brushforms," by Marion Hudson. 5/6 nett. London: O. Newmann & Co.

† It is presupposed that the children who, in their last years of elementary schooling, take part in these lessons, have already practised brushwork. It remains for them to apply principles, which, it will be seen, lend themselves to a botany course like the present one.

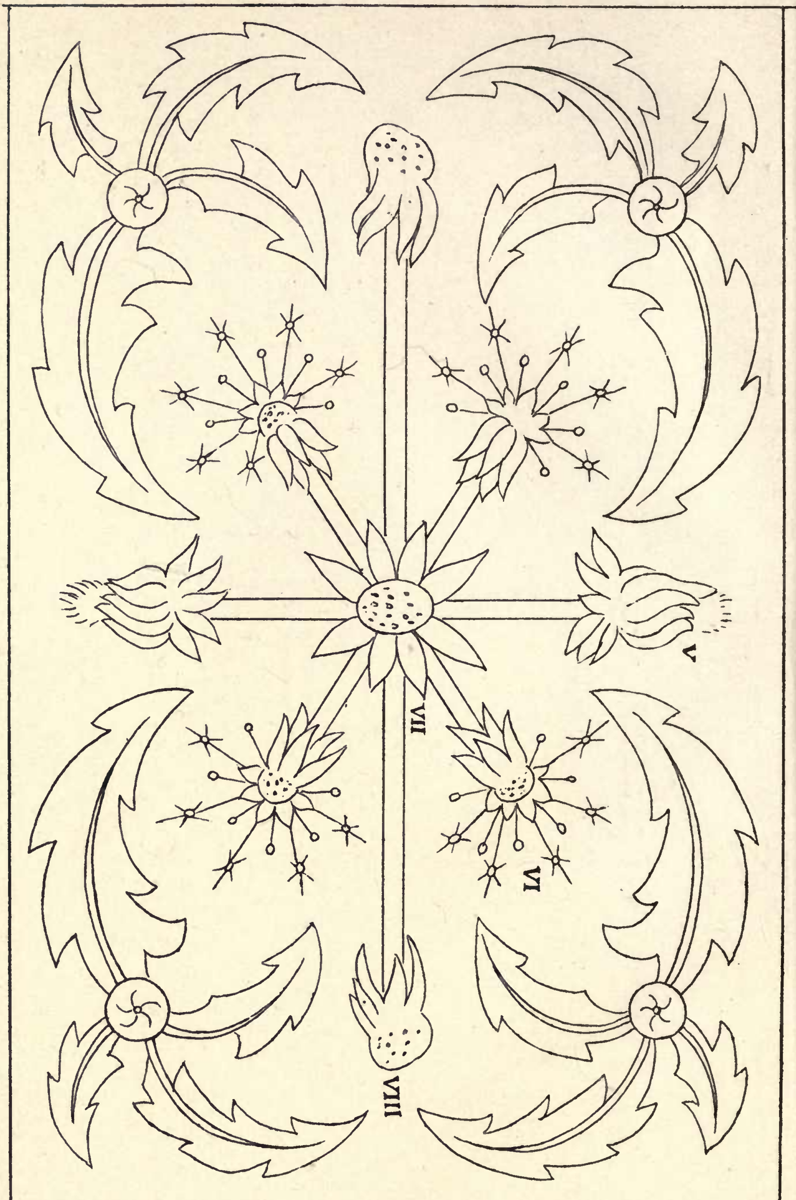



I. II. III. IV. Daisy Buds in profile. 1, 2, 3, 4 full face.
V., VI., VII. flowers half expanded.

The 3 central Daisies (front and back view) are fully open. The Daisy in the middle of the pattern is almost ready to drop. The petals have separated. IX. Ripe pistils surrounded by sepals. 9. Full face of ditto. 10. A further stage, full face and profile. VII. and II. Full face and profile of naked receptacle. 12. Profile of Daisy about to fall.

POCKET BOO

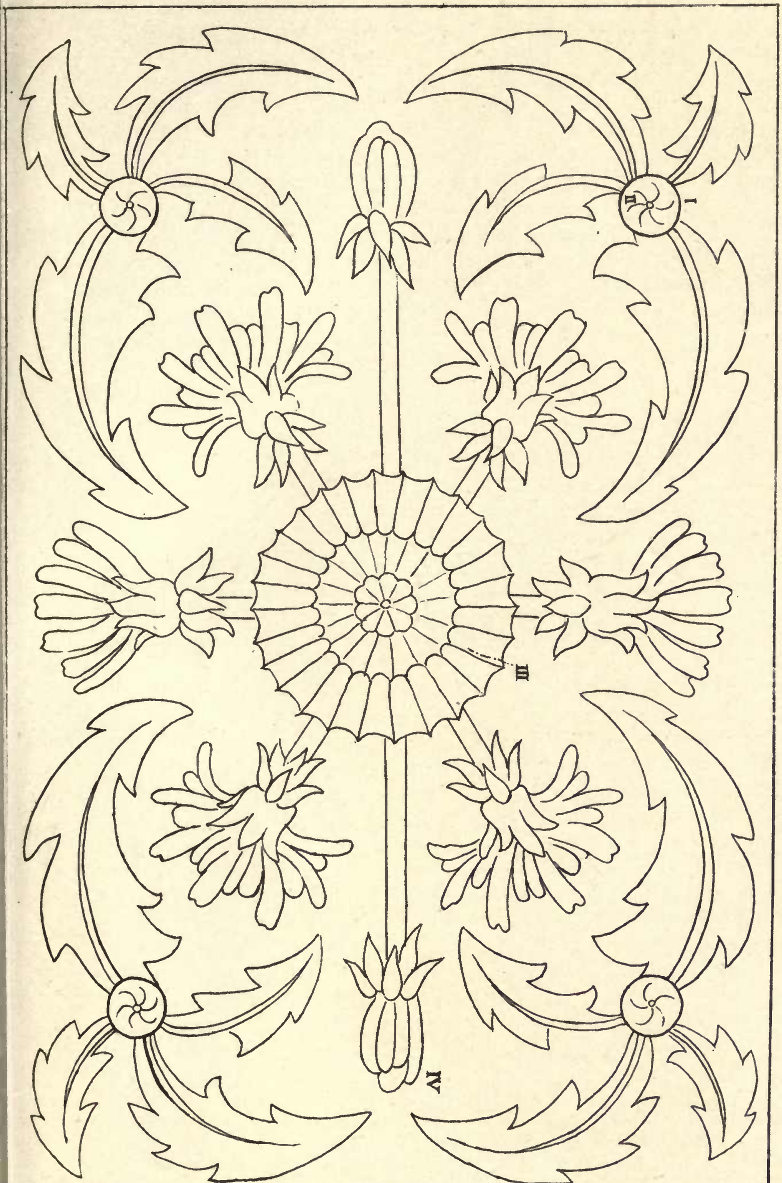
*From bud to full blossom on one side, and fi*




*I. Young dandelion plant. - II. Bud in centre of young seedli*
*round ripening seeds. - VI. Dandelion "clocks." - VII. & VIII. Nak*

-DANDELION.

*fall of floret petals to fall of seed on the other.*




*ant.- III. Full blown blossom.- IV. Bud.- V. Sepals closed*
*eceptacle. (studded with marks left by seeds.)*

An emphasis might be laid on clause (*a*) as applicable to both teacher and pupil. Brushwork copies furnish useful suggestions, and any copy executed by the teacher before the class should be of the nature of suggestion only. Otherwise mechanical and second-hand work is encouraged—as a mere impression of impressions Brushwork becomes degraded.

Coloured chalk, as a substitute for brushwork, involves less apparatus; but however well the preliminary outline may be filled up with lines, the perception of mass, during work, is apt to be lost. We have never recommended a *pencil* or *charcoal* outline to be filled in with colour except in one or two cases where it has been desired that sense of colour should predominate over perception both of mass and outline. In such a case the charcoal will merge with the water-colour and tone it; but it is easier to wash the colour into a space outlined with the pencil.

## III.—Design.

The fault of clever designs, such as are turned out by many of our great Board schools, is poverty of form. It is due to botanical ignorance, and even very good instruction books err in the same way, and give us forms which not only are poor and unvaried in themselves, but are formed by sticking incongruous parts together. The actual habit, spring and growth of a plant are not incompatible with the more or less geometrical basis which is the essence o design.*

Then, also, every blossom wears a dress suited to its age and task. From earliest bud to falling seed-vessel there is a moving pageant of form and colour in each individual plant. The designs in this book are an attempt to balance and order the shapes which Nature colours gorgeously for us on every side. The studies of outline and mass which we recommend should precede each design, should be followed by the construction of a diagram or basis, then by the design itself (see pages 156 and 161) where each stage is illustrated; (see also the little art programme at the end of each lesson). The preliminary studies are intended to fill the pupil's mind with shapes (ready-made abstractions) so that it may be equipped for the task of grouping them. The actual plant may indeed be in the schoolroom, but it should not be under the child's very nose while he is in the act of designing. The design moreover should be made *after* the actual botany lesson, whereas line or brush studies should accompany and illustrate it. The teacher will generally find that the botany lesson has been arranged to

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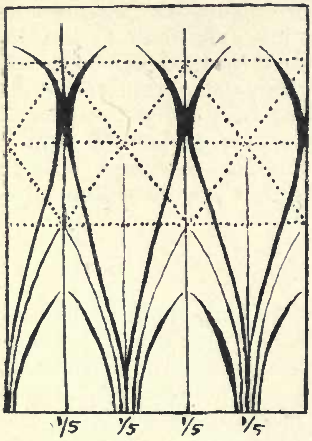
* See basis of the buttercup and plantain design, page 161. In cases where the children have no special aptitude for designing, it may be well for teachers to furnish the geometrical basis on the blackboard; but they must be careful that it is suited to the growth of the plant and as simple as possible. However plain and severe this basis, it is all important. Nature only suggests the ideal balance and measure which geometry bestows. We always fail in design when we seek to rival nature by pure imitation; but when we rule her with a frank conventionality, we may rise above her into the realm of art. A very "natural" design is not "artistic" unless it shows the stamp of the human mind.

occupy but a short time where designing is intended to follow it. The geometrical basis of the design should be even more severely simple than any involved in the illustrations of this work. They are illustrations of method and possible scope; it is hoped that they are too elaborate to tempt mechanical imitation.




Basis of Snowdrop Pattern.

As much of the basis as possible should be drawn freehand. Even the squares and diamonds of diaper patterns may be attempted without a ruler by those children who feel zealously inclined to make the attempt.

Those who are backward should use dotted or half-inch squared Kindergarten paper. Rigour imposed by straight lines is a wholesome corrective to the laxity which is apt to gain indulgence when brushwork additions to the design have to fill the intervals of the "diaper." At the same time, brushwork design is more instructive than design which is purely linear; it compels attention to mass.

**IV.** Paper-cutting and folding is a device of Ruskin in so far as it is applied to vegetable structures. The teacher should draw the diagrams very large upon the blackboard: the children should copy them on paper, cut them out, and fold them up with their own hands. Experience has proved that they greatly enjoy the folding, which brings home to their minds Nature's wonderful skill. How clumsy are their models compared to the real thing! And yet they have tried so hard!

* * * * * *

The variety of artistic accompaniments to the botany course may be objected to. Why not have a course of one subject—such as brushwork only?

1. Because the botany would often suffer from inappropriate illustration.
2. Because overmuch method kills the joy of art. A lump of coal or a camel's-hair brush should be equally welcome means of expressing thought.

The sequence of the botany itself may appear broken; but what says the Board of Education? "The instruction should in every case be appropriate to the season of the year and the circumstances of the locality." Nevertheless a rude progression is observed from the consideration of stem, leaf, flower and seed vessel to that of the inter-relation of these parts as regards both function and origin. The comprehension of the root, the seed,

and the fruit in each case involves a certain amount of morphology, and these parts are not seriously studied until the second year. Man's alteration of forms prepares the mind for Nature's far more subtle variations, and accordingly the autumn of the first year is given up to the achievements of kitchen gardeners. Afterwards, in dealing with the Rosaceæ, we stumble across freaks produced by fruit growers and horticulturists; then at last we find freaks of Nature's own, wherein, as it were, she forgets her reticence and discloses the wonderful fact of her unity in the midst of her infinite variety.

Man's attempt to attain an artificial unity by means of classification is explained with reference to the very few simple families under discussion; involving the distinctions between monocotyledons and dicotyledons, as also distinctions between the chief divisions of each, viz., between lilies and grasses—the melon (Monopetalæ), and the wallflower (Polypetalæ).

Cordial thanks are due to Mr. George Allen for his generous permission to use the following:—Fig. 10 of "Modern Painters," Vol. V., on page 10 of this work; Figs. 21, 22 and 23 of "Proserpina," on pages 19 and 20; Figs. 13 and 14 of "Proserpina," on page 63.

UTTOXETER,

*April, 1903.*

# OBSERVATION LESSONS ON PLANT LIFE.

## PART I.—FIRST YEAR.



### 1.—BUDS AND SCARS.

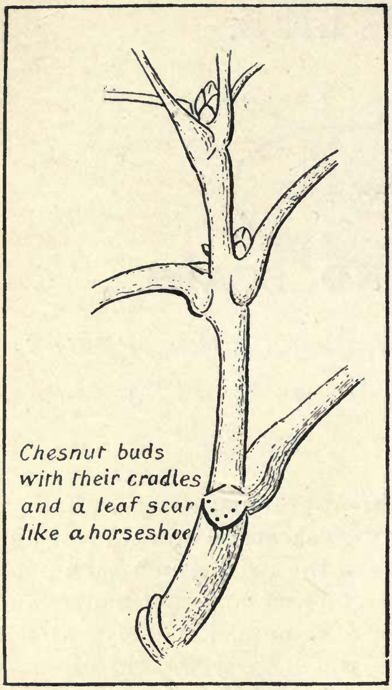
(*FIRST WEEK OF MARCH, OR EARLIER, IF BUDS ARE SUFFICIENTLY DEVELOPED.*)

**Parts of a twig.**

Four generations of life, great-grandfather, grandfather, father and baby son—in other words: stem, branch, leaf and bud—contribute towards the life of the twig, which each pupil should hold in his hand. The children may not understand any such family history all in a minute, but the next few lessons are intended to explain it. "*Every leaf has assuredly an infant bud to take care of, laid tenderly as in a cradle, just where the leaf stalk forms a safe niche between it and the main stem.*"—RUSKIN. This statement applies without exception to all branched growths. Sometimes, as in the variegated laurel, the bud is so small as to be almost invisible, but nevertheless it is there. Pull the leaf stalk well away to its very base and a green knob, less than a pin's head, will be seen. Let some such big bare twigs as those of the horse-chestnut tree be next examined. Branches and buds are there, but the leaves fell off last autumn. Let the children try and remember how long buds have been visible. They started a great while since, during their parents' lifetime; for each bud is a leaf's baby—an heir of the family property and of the family task. Perhaps one day some of the children may understand what is the task, and what the inheritance to which each bud is born.

**To each leaf his scar.**

The situation of a leaf is recorded by its bud, and also by its own individual life mark—the scar which it leaves behind it when it dies. Tear off a holly leaf, and its former place can be found by a mark left in the bark. Compare the very different shape of horse-chestnut scars. The leaf of each kind of tree makes its own kind of scar, and a big prosperous leaf makes a much bigger scar than the poor little leaf which has hardly heart to live, and whose bud often dies. On the other hand, a bud with a large scar beneath it is likely to live strongly and to do well. This is important to pruners.




**To bud scales a ring of scars.**

What do baby buds become when they grow up? The children may watch them swell and open, and they know that soon the trees will be green with leaves. These leaves must have been tucked away inside the buds—large as those are, and the buds so small! We shall see about that presently, and also try to find out whether one or more leaves go to make a bud, and whether a bud grows into anything else but leaves. First, let each child be provided with a big bud of, say, horse-chestnut, to pull to pieces. Outside it is brown in colour, hard and sticky to the touch. Ordinary leaves are soft and green; and yet sometimes, on currant bushes especially, the coverings of the bud remind one of leaves. These coverings are called "scales," and they keep the bud warm and dry. Look at the way they lie over one another, like the scales of a fish or the slates on a roof.

When spring comes the growing leaves force open their prison, and the scales lie in a thick carpet on the ground. They leave their mark behind them just as leaves do, but whereas leaf scars occur singly, scale scars are to be found in rings round the stem. Which child can explain why?

**The bud is a baby stem with leaves or flowers, or both.**

So much about bud scales. Now let us unpack the shielded centre of the horse-chestnut bud. Sure enough the leaves are there—not one only, but several tiny things, closely folded on themselves and on one another. Sometimes quite in the centre of the bud may be found a wee candelabra of chestnut blossom—that dear white torch of June. It is so small and so over-wrapt with soft down as to be hardly recognisable.

Different kinds of buds should be compared. On some trees (*e.g.* the apricot) the blossom occurs in a bud to itself.

When the bud swells, this means that leaves (and blossom, if there is one) have begun to grow, and the stem to lengthen.

Let us pause here to see if any child knows how a stem lengthens. If it grows at the point only, the leaves will be left behind, and when they increase in size they will crowd each other inconveniently; instead of which we know that nature gives every leaf room to grow. But the stem lengthens *between* the leaves, and we can reckon its growth by looking at the spaces between the leaf scars on a twig.

**The year's growth is called a shoot.**

As every twig ends in a bud, so the branches of the whole tree grow simultaneously year by year. A year's growth, that is to say, the new part of each twig, is called a "shoot." A new shoot is formed each time that a bud wakes up rested from its winter sleep. We can tell that buds, however young, are complete before ever winter sets in, for if a twig is kept in water in a warm room the buds burst, thinking it is spring, and begin to grow.

**Age of twig told by scar rings.**

By next autumn the scars of the bud scales will be left far behind the tip of the twig, owing to the growth of the

bud into fresh stem. The same thing has occurred before, for each year's growth leaves a ring of scars, and by counting the number of rings we can reckon the age of any twig.

**Summary.**—A bud is a baby stem with leaves or flowers, or both, and it comes in the joint of a leaf with the stem. Leaves and bud scales leave scars on the bark when they fall off.

**Drawing.**—Let the children outline, in slate or lead pencil, an evergreen shoot, with special attention to the buds, and to the way in which the leaf stalk holds them. Some large kinds of ivy are good instances.

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## 2.—FROM TWIG TO TREE.

(*SECOND WEEK IN MARCH, OR EARLIER.*)

**Variation of buds.**

The buds on a twig grow like brothers and sisters: one broader, another taller, and each has different work to do—in other words, a different gap to fill in the growth of the whole tree. The buds on a variety of twigs should be compared, and it will be seen that large and small buds occur in relatively similar places. For instance, the final bud is the biggest, and some day it will produce the longest and thickest shoot of any. The pair of buds underneath it is usually very tiny, as is also the lowest pair of all.

**Sleeping buds.**

Perhaps some of the number, though still remaining on the stem, have rotted and died. Theirs is a mere pretence at life, and the pruner must beware. Others are lazy, and shirk work. Last spring, instead of waking up and growing like the other buds, they just slept on; but still, they may yet rouse themselves, and grow into branches, should the tree need them. Some time or another a branch in their neighbourhood may die, and then they will have to bestir themselves and fill with growth the gap which has been left.

**Branches often fewer than buds.**

The tree cannot afford to let all its buds grow into branches. A rapidly-growing bud, like a fat baby, takes a lot of food, and the parent tree has not enough for all its buds at once. Supposing the buds *could* all be fed—a choking crowd of branches would result. (This can be proved by a diagram on the blackboard.) Also, the tree would possess no reserve of force.

**Death of buds and result.**

A comparison of branched growth proves that the tiny buds at the bottom of a twig are usually the longest asleep. Now buds sometimes die before they have seen the course of even a single summer. Then there is more food for the survivors, and buds which have slept suddenly sprout. Let the age of the oldest dormant buds be reckoned, or of one-year shoots which must have sprung, once upon a time, from dormant buds.

**Loss of leader results in a fork.**

Let the children hunt for a death sign of the leading bud on a forked twig. Supposing the "leader" never died, the twig would have a direct central stem, for the nature of a shoot, so long as it is not interfered with, is to grow straight to the light. But a chestnut twig, for instance, does not show a main stem. It forks, instead, at fairly regular intervals, into twin branches. At the angle of each fork may be found a short rotting spike, or else a round scar—evidently not a leaf scar. The branches of the fork sprang from a pair of buds, as the opposite leaf scars testify. The leader of the stem must have been placed between and above this pair of buds. Perhaps the children may find out soon why chestnut leaders have a way of always dying, leaving the forked twigs behind them.

**Unequal yearly growth.**

The stem does not grow to a similar extent each year, for it will be found that a short specimen bearing only two pairs of buds, instead of four or more, usually forks in a year's time at the place where the upper pair occurs. The tip of the stem

shows a round scar where it broke off. Long and short growths often occur year about.

**Terminal flowers cause forked growth.**

It will be remembered that on some trees flowers are alone in the bud, and when this is so, it always leads the way, as if it were better than the poor leaf buds. But in time the proud blossom withers. Now let children think and see how it is that forked growth occurs with leaf buds foremost at last. This forked growth often begins in the selfsame summer which sees the flowers fall back and die.

The children should practise making out the age and history of various twigs on the black-board or on their slates. Sycamore twigs are interesting for this purpose. Terminal flower buds occur even oftener than they do on the chestnut, and consequently the growth of the sycamore is the more branched of the two.

**What applies to the twig applies to the whole tree.**

Now let the reason be explained by the pupils: why has the spire-shaped fir a straight continuous stem, while sycamore and chestnut are rounded and spreading, with many divisions of the trunk? The moral of the answer being that twigs are only small branches, and branches are only the lesser stems of the tree.

**Summary.**—The stem produces buds of given size, at given places, the larger buds producing the longer shoots, and the smaller often remaining dormant for several years, or dying. In cases where the flowers are terminal, growth is continued by side-leaf buds, and the tree is consequently spreading in habit.

**Drawing.**—A young sycamore, or other tree, 2 ft. or 3 ft. high, cut out of any hedge or thicket, and stuck up before the class, would make an instructive object for simple outline on slate or blackboard, and drive the above lesson home.

# 3.—SPACE AND LIGHT AS GOVERNING FORM.

(*THIRD WEEK IN MARCH, OR EARLIER.*)

**Lack of light causes death of interior shoots and of lower branches.**

Which part of the twig is grandfather or great grandfather to the rest? The buds shoot outwards, so the youngest part of the twig, and therefore the youngest part of a whole tree, is on the very *outside;* the oldest part being the trunk or main stem.

It was found that many chestnut buds sleep and that many die: the youngest portions of a twig show the most wakeful and pushing buds. We must conclude, then, that buds (and even grown buds, *e.g.* branches) die as the twig gets older, otherwise as many side shoots would grow on the older parts of the twig as on the younger. Some die because they have no room, others do not seem to avail themselves of the plentiful space which we find towards the interior of a tree. If we stand beneath the centre of one in summer we can see a long way up through the wide gaps in the branching. The leafy twigs, like the cover of an umbrella, seem stretched on a framework of spokes. Want of space, then, is not an invariable excuse for lazy buds, neither is it always the cause of death.

Again: How can the long bare trunks of trees be accounted for? The naked stems of a thick firwood strike wonder—how did they grow so tall without branches? These must have died or else their parent buds. In fact, the lower boughs of a fir are usually in a dead or dying condition. Below them the scars of former branches are to be seen, and beneath all again, on the ground, lie the dead pine needles without a blade of grass between them. Nature is in a brown study, even the song-birds are far away. Exaggerate the darkness and the stillness; heighten the far-away roof of branches—green on its sky side—and the children may fancy

themselves in a tropical forest.* But the sun looking down from above sees only brightness and colour: every green thing looks up to him for growth which depends on light.

The increased upward curve of branch tips, according to the lowliness of their position on a tree, may be illustrated by a blackboard diagram. The greater their difficulty, the greater their effort to escape from a prison of shade.

**Relation of buds to light.**

The buds, also, seek light and their size is determined by the result. The outermost growers are the most successful, and accordingly they are bigger than the rest, and produce the strongest shoots. The inner shaded buds are stunted, and usually only sprout when neighbours come to grief. In winter, when there are no leaves, it is most easy to realize the effects of shade, but if we were to examine the trees in summer we should find that the largest leaves are the outermost, and the largest buds grow in the joints of these.

**Relation of leaves to space.**

The spaces between the buds of the sycamore, if compared to those which occur between the buds of a chestnut, will be found smaller than the latter. An explanation is suggested by the size of the leaves. Large leaves must have a long interval of stem if they are to avoid shading and cramping each other. In other words, if they were too much mixed up together they might quarrel.

**Opposite arrangement of leaves.**

So the buds are kept in good order,—neither too many of them nor too few, and each in its place along the stem. One of them, if plucked away, causes a notable break in the arrangement and is missed at once. The chestnut buds will be found to grow in pairs, the buds composing a pair being placed exactly opposite to each other on the stem and as far as possible from the next pair without waste of space. These intervals between the bud-couples correspond pretty closely on all shoots growing under the same conditions of light,

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* The high close forest of the tropics must not be confused with mere jungle, which, of course, *has* luxuriant undergrowth.

room, etc. This is called the "opposite" arrangement of leaves. Sometimes more than two leaves grow together and then they form a high collar or "ruff" round the stem. (Specimens of woodruff or other whorled growth should be before the class.)

**Alternate arrangement of leaves.**

How do the buds on an elm twig differ in plan from those of the chestnut or sycamore? They come singly at intervals up the stem. This is called the "alternate" arrangement of leaves. If we were to do away with the interval between opposite buds on the elm so as to make them come in pairs, how would the arrangement still differ from that of the chestnut? In the latter, the bud couples do not come exactly above one another so as to overshadow, but they alternate on opposite sides of the stem. If lines were drawn down the stem from bud to bud, four would be required to cover a sample of the bud plan; but in the elm, two lines would suffice.

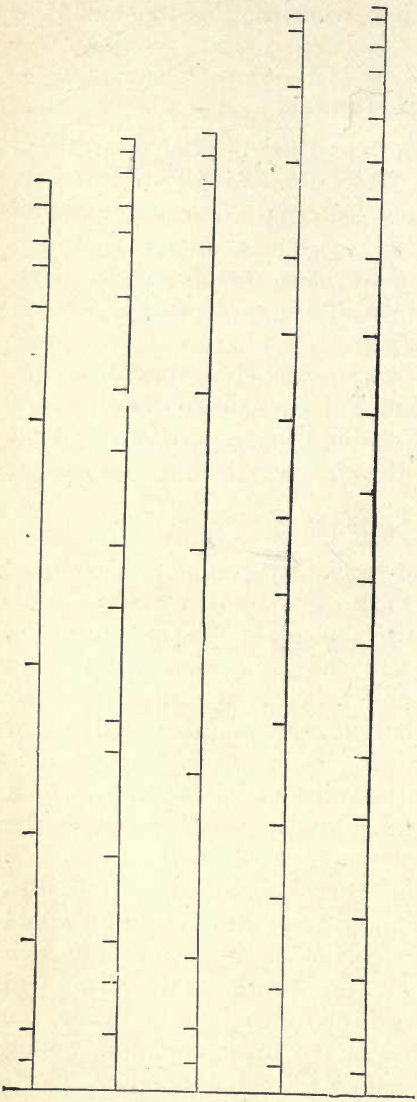
**The wide and the close spiral.**

If string were wound round an elm twig so as to pass over each bud in turn, a wavy line called a "spiral" would result. (Cf. a corkscrew or a gimlet.) An apple twig (oak, plum, peach or cherry will do as well) shows a closer spiral than the elm, for the spaces between the buds are much shorter, especially near the tip of each twig. The leaves can follow very closely without overshadowing each other, because it is the sixth bud only, instead of the third as in the elm, which comes over the first. When wound twice round the stem the string covers five buds, none of which grow in the same line one above another. Each bud, therefore, occupies one-fifth of the circumference of the stem, and five straight lines would have to be drawn downwards for one to pass through each bud. In the case of a pear twig, three turns of the string will be found to cover eight buds and the ninth bud is below the first. But the apple plan of five is the most common among trees. There are other arrangements besides these.

**Twisting of stems.**

Sometimes the order of buds is broken, owing, perhaps, to deaths. Occasionally two seem to come on the same side

of the stem, whereas they should really be opposite. This appearance may be produced by the twisting of the stem, often occasioned by a search for light. We can see the twisting of stems on a large scale in the trunks of hawthorns and of beeches.


A C B D E

**According to the position of the buds, so the shape of the tree.**

Naturally the shape of the twig, and therefore of the whole tree, depends upon the position of the buds—for branches grow where buds have been. Let modes of forking in the chestnut and in the elm be compared.

**Summary.**—Leaves are arranged on the stem in a regular order, which secures for each leaf the greatest possible amount of light. To this end the arrangement of leaves up the stem usually follows a spiral. The position of leaves determines, of course, the position and flow of the branches — but many of these die sooner or later from want of space, and light.

The hints on design at the end of Lesson V. ought properly to follow here, but the lesson is too long and necessarily difficult to be

accompanied by drawing. Instead, the children may profitably follow out the directions given by Ruskin in "Modern Painters": "Take a piece of stick half-an-inch thick and a yard or two long, and tie large knots at any equal distance you choose from one end to the other, and the knots will take the position of buds in the general type of alternate vegetation. By varying the number of knots and the turns of the thread you may get the system of any tree with the exception of one character only, viz.: that since the shoot grows faster at one time than at another, the buds run closer together when the growth is slow. You cannot imitate this structure by closing the coils of your string, for that would alter the position of your knots irregularly."

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## 4.—FRUIT SPURS.

(*FOURTH WEEK IN MARCH, OR EARLIER.*)

**The "Spur."**

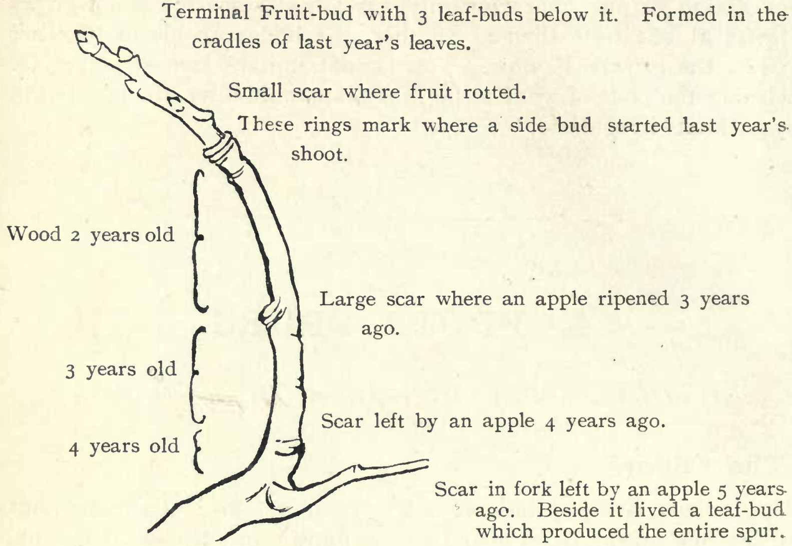
In case the pupils have never seen a spur, let the teacher draw one on the blackboard and explain what the word means. Then each child should examine twigs of various fruit trees to find, if he can, anything which reminds him of the shape he has seen. Short curved offshoots are called "spurs" by pruners.

**The fruit bud.**

Before proceeding further about spurs, it must be clearly understood what is meant by a "fruit bud." It has been noticed that buds differ in size according to position. In apple twigs for instance it is very noticeable that the terminal buds are fatter than the rest. If the children pick one of these buds to pieces they will find that size is not merely owing to plentiful light and food. These buds have a great deal packed away inside them, to wit, a baby stem with leaves at its base, and flowers at its tip—the future apple crop. These fat flower buds, to which we afterwards owe the fruit, are called "fruit buds."

**Forked spurs.** (THE APPLE.)

Spurs, wherever they fork, show the same scars which the children saw upon chestnut twigs. Comparison of different trees will show that fruit buds occur in a variety of positions, but in the apple they are always formed at the tip of the spurs,




HISTORY OF AN APPLE SPUR.

and sometimes, but rarely, the main shoots (which give off the spurs as side branches) end in a fruit bud. Then they, as well as the spurs, have to fork.

**Scars tell spur histories.**

Sometimes a group of small scars may be found on an apple twig instead of a single mark, and it will be found that wherever the scars are isolated they vary very much in size. Now do apples grow alone or sociably? The children should try and remember whether they have seen single or clustered blossoms on the trees in spring. This question should lead to an explanation of the two first-discovered facts, viz. the size and number of the scars depend on how long the apples remained on the tree, and how many there were of them. If flowers fall before the fruit "sets" very small scars are left.

An apple spur should be drawn in colossal scale on the blackboard, and the pupils should tell its history. Every stage of a spur's upbuilding is marked upon its surface.

A hint which may help in this history tracing is that buds which formed in the joints of the leaves below last year's fruit, may have begun to grow in that same year, especially if the fruit dropped before it was ripe. A swelling apple takes a great deal of nourishment from the parent tree, and unless it perishes prematurely, the buds below it are not sufficiently well fed to push out at once. So, as a rule, a spur flowers and puts out leafy shoots once in two years. A very good apple year is usually followed by a poor one.

**Straight spurs.** (1. PLUM.)

The spurs of a plum tree should be compared with those of an apple tree just described. They go so straight ahead that it is evident that the fruit buds are *not* formed on the tips of the shoots. The buds, moreover, come in twos and threes. Sometimes a group of these contains fruit buds only, but generally there is a leaf bud also. However, it frequently happens that, in the end, only one bud of the two survives.

(2. APRICOT.)

The apricot and peach are also straight growing, so it may be concluded that the fruit buds are lateral. Two-year-old wood shows large single scars, above which no bud occurs. It will be remembered that leaves are always accompanied by buds; therefore they cannot be leaf, but fruit scars; and the fruit must be borne singly. It is easy to find, however, on last year's wood, a trio of buds, the two at each side being large and thick, and evidently fruit buds. It will be noticed, therefore, that, as a rule, one leaf bud and one fruit bud die. We can understand now why the bases of plum and apricot spurs are devoid of secondary side shoots, and are lumpy with scars. If the trees were being pruned great care would have to be taken to leave a number of young shoots.

**Summary.**—The short side shoots of fruit trees are called "spurs," and they are crooked or straight, according to

whether the fruit buds are terminal or lateral. Lateral fruit buds are often formed in couples or with a leaf bud, but if one of the fruit buds "sets," the other two buds do not often survive. The history of the fruit can be told by the size of the scar.

**Drawing.**—Let a variety of fruit spurs be outlined in a row side by side as a guide to design, to contrast their several modes of growth. According to the position of the buds the outlines will be rugged or even flowing in character. In bad drawings a rugged outline is often given without reference to explanatory buds. Chestnut twigs would be simpler to draw, but less instructive. All this has an important bearing on pruning.

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## 5.—OUTSIDE GROWERS.*

(*FIRST WEEK IN APRIL, OR EARLIER.*)

**Woody and herbaceous stems.**

What is the difference between a bush and a plant—popularly so called? It cannot be merely a matter of size; consider, for instance, how much taller a sunflower grows than a gorse bush. We get at an answer if we consider that some sunflowers die altogether when the frost sets in—other kinds "die down," to come up again next year; but the gorse bush does not die down—the frost does not harm it. The stems of a bush are hard and "woody" and live more than one year, whereas those of a plant are soft and juicy in comparison, and the frost kills them.

**Fibre and Pith.**

Who knows what rhubarb is? The part we eat separates into strings or "fibres," and forms the stalks of leaves. All

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* "Outside grower" is simply a translation of "exogen," which is a difficult word to children. Ruskin talked about outlaid and inlaid plants, but these terms involve a departure from the literal sense of "exogen" and "endogen."

stems are made up of "fibres" and pith, except when they are very young, and then they are all pith. Notice in what the pith differs from the wood. It is of a spongy nature. The children may split a twig carefully out to the terminal bud to find out whether the pith reaches the bud. Fibres grow in long-shaped bundles—think of a faggot of sticks or a sheaf of corn. Already, in a single summer's growth, these bundles form a ring round the pith in the very centre of the stem. If thick stalks are rudely torn asunder, the fibres hang out at the broken ends. A cabbage leaf-stalk shows this well. Rays of pith will be seen to radiate from the centre of the stalk to its circumference, like the spokes of a wheel. Compare the wood found in the rays with that about them. Children may remember how the horse chestnut leaf scars are dotted. These dots are marks left by fibre bundles when they break off.

**How to tell the age of woody stems.**

Fibres constitute a stem's toughness—they are its "wood" —the muscle of the tree. Every year new wood grows just outside the last fibre bundles. Former bundles shrink together, and the pith rays consequently draw closer whilst the new wood forms a surrounding ring. Year by year this fresh ring is formed between last year's wood and the bark, and thus the stem gets stouter and stouter, and its age may be told by counting the rings. It will be noticed that some rings in a stem section are thicker than others, and this points to a variation in the extent of yearly growth. Notice also whether the rings are alike in thickness on all sides of the branch. Compare the north and south side of a stump of a tree. On which side are the rings closest? Some trees (like some people) have a constitutional tendency to stoutness, *e.g.* the chestnut which has to carry great spreading branches and broad leaves that catch the wind like sails. A chestnut leaf may be compared to an umbrella open towards the wind, whilst pine needles resemble an umbrella that is tightly folded. Which, let the children say, has the harder task to resist a storm—the pine tree or the chestnut?

**The Bush *versus* the Plant.**

Now let us return to the difference between plants and bushes. Bush stems are hard simply because they have more

wood than pith, and *vice versâ;* young shoots and stems of plants that die down are tender because they contain more pith than wood (old elder twigs are good examples of pithy softness). The pith is dry, and should be compared to the juicy, sap-filled pith of young wood.

**Causes of fibrous strength. 1. Elasticity.**

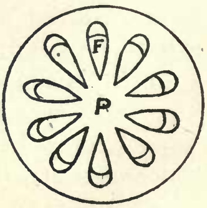
Now what is it that enables young sappy leaf stalks to bear against the resistance which leaves offer to wind and rain? What is it that makes the village pond bear up under hundreds of skaters one day, when another day it will crack across with a very slight weight? Not only the thickness but another cause also. The first day the ice is fresh; the second it is rotten. In other words, it will not bend or give way, but snaps off quite sharp when it is opposed to resistance. This is what the leaf stalk does when it is old. But while it is young, the fibres give way and spring back when resistance is removed. The wind may bend it nearly double, but back it springs to its former position directly the wind slackens. When the stalk becomes more woody, it also becomes harder; but at the same time it is more brittle.

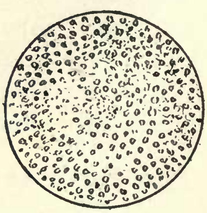
**Causes of fibrous strength. 2. Roundness.**

A rounded surface is always stronger than a flat one. Let the children make flat paper spills and round ones (by rolling paper), and see how much more easily the flat spills are bent than the round spills. Leaf stalks, when much hollowed, may be compared to a round spill split in half downwards.

Sometimes the leaf stalk resembles an open water gutter along its whole length, as in the lesser celandine, and children should be asked to watch the rain running down to the roots on a wet day.

OUTSIDE GROWER.



INSIDE GROWER
P=pith. F=fibre.

**Inside growers.**

The stems we have been talking about, the wood of which is in rings, are called "outside" growers. But there are other trees and plants of which the fibres are

not arranged in a circle, and where the new wood consequently does not form rings outside the old. The fibre bundles are dotted about — scattered in an irregular way through the pith of the stem. These plants and trees are distinguished by the name of "inside" growers, and will be considered in the next chapter.

**Summary.**—Plants die down, but bushes persist from year to year, thanks to their woody stems. Fibre owes its strength to (1) elasticity and (2) roundness. The bundles of fibre are arranged ringwise in outside growers, and are scattered irregularly in the pith of inside growers.

**Drawing.**—Recapitulation of all the preceding lessons would be achieved by a design composed of the characteristic branchings of various outside growers. Nearly always in design we see any leaf stuck upon any stem, *anywhere*, just as if there was no relation, apart from decorative propriety, to be observed. It need not be supposed that a concealment of the stem obviates the necessity of knowledge, for masses of foliage with no stem visible tell a tale of bud arrangement. The oak, for instance, thanks to its bud plan (see ch. III.), presents clusters of stars composed of five leaves each.

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## 6.—INSIDE GROWERS

(*SECOND WEEK IN APRIL OR EARLIER.*)

**Nature of Stems: Recapitulation.**

Stems are composed of pith and (except in the very earliest stages) of bundles of fibre. If the fibre bundles are arranged in a circle the plant is an "outside grower." On the contrary, if they are scattered about in the stem, the plant is an "inside grower."

**English inside growers.**

Corn, grasses, rushes, lilies, etc., belong to "inside growers," but all these are all plants which die down in the winter. There

are no trees of this kind in England. Bamboos, which are so largely used in the construction of our furniture and in the manufacture of fishing-rods and of walking canes, are examples of inside growers, and sometimes show excellent sections. In small stems of only one year's growth it is not easy to make out the scattered fibre bundles, but an inside grower may be recognized by other points.

1. **Parallel** *versus* **netted venation.**

Let the manner be noticed in which lines radiate, in some leaves from stalk to margin. The radiation, or branching, varies according to the kind of leaf. The main lines standing out behind remind one of veins on hand and arm. These veins really support the leaf like the scaffolding of a building. The intermediate green parts may be soaked away and a skeleton leaf is left. (Leaves should be at hand soaked for illustration, or the children should be asked to prepare skeletons.) The leaves of outside growers display a perfect network of minute veins. But a blade of grass runs its main veins side by side without forking or touching, though they draw closer to one another as they approach the tips. Straight-veined leaves are usually long in comparison to their width. The leaves of inside growers are all straight or "parallel" veined, whereas those of outside growers are "net veined."

2. **Absence of leaf scars.**

The scars left by the leaves of outside growers have been noticed before. Now for an interesting puzzle. If we pull at grass blades they tear and leave a ragged edge. Let the real beginning of the grass leaf be discovered. It wraps the stalk round like a sheath at a ring-shaped joint, and does not flatten out until some way after its start. The leaves of outside growers never indulge in similar freaks, but they are most frequent in inside growers, the result being that leaf scars are absent.

3. **Absence of buds.**

Can any other strange thing be discovered in connection with these inside growers? Did we not find that the leaves of outside growers always cradled buds? But corn and grass

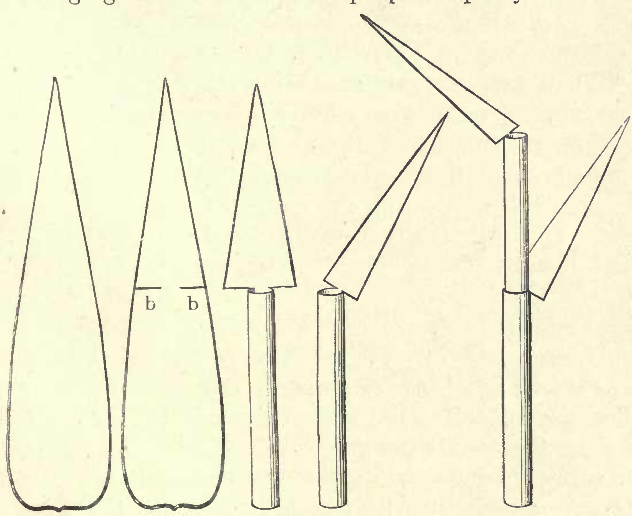
and rushes have no buds in their joints. Consequently do these plants ever branch? Let those children who have seen pictures of palm trees try to remember whether they branch or no.

There is another way of recognizing inside growers, viz. in connection with their flowers. We shall consider this point.

**Summary.**—Outside growers may be distinguished from inside growers by their net-veined leaves, whereas the leaves of inside growers are parallel-veined, often sheathing the stem, leaving no clean scar when broken off, and producing no buds in their joints. But the chief distinction of all is this: that in outside growers the fibre bundles occur in circles, whereas in inside growers they are scattered throughout the stem.

**Paper folding and cutting instead of drawing.**

Inside growers sometimes turn the faces of their leaves skywards; and sometimes their edges. In order to understand how these two positions are respectively managed, let a corn plant be cut out as directed by Ruskin in "Proserpina," p. 176, and also a flag (p. 180). If no flags grow by neighbouring water, an iris out of any cottage garden will serve the purpose equally well.

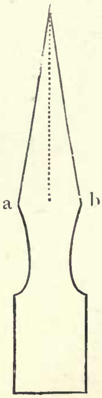



* "Cut out a piece of strong paper into the shape of (*a*). Now suppose the next young leaf has to spring out of the front of this one, at about the middle of its height. Give it two nicks with the

* From pp. 175 and 176 of *Proserpina*, by John Ruskin.

scissors at *b b;* then roll up the lower part into a cylinder (it will overlap a good deal at the bottom), and tie it fast with a fine thread. So, you will get the form at *c*. Then bend the top of it back, so that, seen sideways, it appears as at *d*, and you see you have made quite a little flower pot to plant your new leaf in, and perhaps it may occur to you that you have seen something like this before. Now make another, a little less wide, but with the part for the cylinder twice as long; roll it up in the same way, and slip it inside the other, with the flat part turned the other way, *e*. Surely this reminds you now of something you have seen, or must I draw the something?

* "You felt as you were bending down the paper into the form *d* (first figure) the difficulty and awkwardness of the transition from the tubular form of the staff to the flat one of the flag. . . . . Cut out another piece of paper like *a* (first figure), but now, instead of merely giving it nicks at *a*, *b*, cut it into the shape *A* and roll the lower part up as before, but instead of pulling the upper part down, pinch its back at the dotted line, and bring the two points, *a* and *b*, forward, so that they may touch each other. *B* shows the look of the thing half-done, before the points *a* and *b* have quite met. Pinch them close, and stitch the two edges neatly together, all the way from *a* to the point *c;* then roll and tie up the lower part as before. You will find then that the back or spinal line of the whole leaf is bent forward, as at *B*."



A


B

Ruskin intends this piece of "disciplined paper" to teach how *strong* the iris leaf is—"twice as strong as a blade of grass, for it is the substance of the staff, with its sides flattened together, while the grass blade is a staff cut open and flattened out." And as a grass blade "necessarily flaps down," so the leaf of the flag or iris "necessarily curves up, owing to that inevitable bend in its back." Botanists have named such leaves after a sword, because of their "keen edge, and long curve and sharp point."

* From pp. 179 to 181 of *Proserpina*, by John Ruskin.

These exercises of Ruskin's device are unique, whereas they might profitably be imitated and applied to illustrate many modes of growth, and also of leaf and bud folding. The materials required are simply paper, pencil and scissors (a ruler and compass might sometimes be added). Hand and eye assisting in the lesson, the ideas derived will be driven home most forcibly. See Nature Studies 22 and 38 for diagrams of leaves, and Studies 63 and 72 for diagrams of fruit to be folded and cut.

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# 7.—THE WALLFLOWER (1).

*(THIRD WEEK IN APRIL OR EARLIER.)*

**"Sepals" cover the flower bud.**

Let wallflower buds be explored that are just about to open. First come four brown leaves called "sepals," which wrap up the bud entirely after the manner of leaf-bud scales: only these take care of a baby flower instead of an infant shoot. They are arranged in pairs, one of which bulges considerably at the base. If we wish to discover the reason of this oddity we have a riddle to pause and puzzle over.

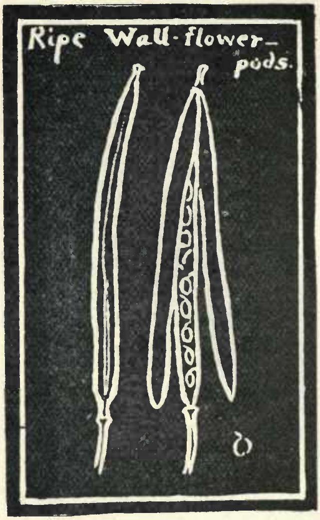
**Four "petals" are within the bud.**

Next let a full-blown flower be examined. The four-coloured leaves called "petals" are placed in the form of a cross, alternating with the sepals. It will be remembered that they capped each other tightly and snugly in the bud, thus helping to roof over the middle part of the flower. Here they seem released from such duty (though perhaps they may return to it in the chill of night): each has grown very much, and throws itself back from the end of a long, narrow claw, leaving the centre of the flower wide open. "Petal" means something which is "spread out."

**Stamens within these again.**

Inside these charmed circles of sepals and petals we find six slim stalks, finer even than the coloured claws, of which

they remind us a little. In double or imperfect wallflowers these stalks sometimes flaunt bits of coloured blade, in which case they to a great degree resemble the petal claws. An arrow-headed tip is at the end of each stalk, and the children


should prick it to find out whether it is solid or hollow. They will ascertain for themselves that it is a double bag filled with dust, which may be shaken out in clouds from full-blown flowers. These bag-tipped stalks are called "stamens," meaning "threads."

**Two stamens are weighed down by honey bags.**

Perhaps the shape of the stamens may help us to solve the above-mentioned riddle concerning why a pair of sepals bulges: and, sure enough, two stamens will be found bending into the brown covering leaves, thus giving them an outward thrust. But this only brings us to a second riddle: What is it that gives these stamens a crook in their back? Truth to say, the poor things are borne downwards by a great load—nothing less than a bagful of nectar apiece.* Let each child prick the green, swollen lumps and find out for itself by tasting that there is a sweet juice inside. Some day it shall know why the flower stores up goodies.

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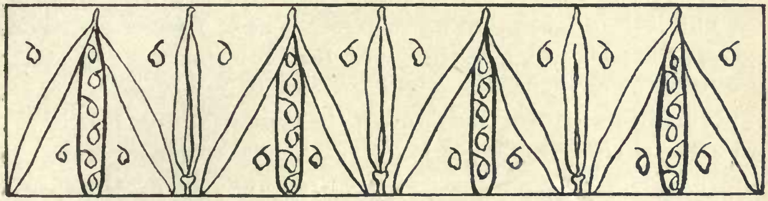
* Nectar is the raw material of honey.

Something yet remains in the centre of the flower. Not a petal nor yet a stamen. We will enquire into it in the next lesson.

**Summary.**—The wallflower is protected by four brown sepals. Inside these, four petals help to enclose the stamens. These are threads bearing dust bags. Two of them are weighed down by swollen lumps containing nectar.

**Art.**—Let studies of wallflower petals be made in brushwork, and if the leaves be variegated, the manner in which strips of colour converge in the claw, should be carefully noted. Studies of the linear seed-vessels and leaves may also be made; they are a pleasant contrast to the broad-winged petals.



SPLITTING PODS.

# 8.—THE WALLFLOWER (2).

(*FOURTH WEEK IN APRIL OR EARLIER.*)

Let the last lesson be re-capitulated.

**The folding of petals in the bud.**

Let us re-examine wallflower buds. The big petals fold into a very small space, yet they do not crumple. Compare with slates overlapping on the roof. As the sepals shelter the petals, so do the petals protect the inner parts.

**The pistil is the innermost, most protected and most lasting part.**

The stamens, in their turn, stand very close round the most central thing of all—helping the leaves to cover it up.

How precious it must be, kept so warm and dry and tight in the centre of the flower! And yet it is only a little forked spike standing on a swollen base. It is called the "pistil" or "pestle," because it reminds one in shape of the pestle which cooks use in a mortar—the hollow bowl of the flower being perhaps like the latter. In the oldest wallflowers the pistil has strangely altered in shape, being longer and narrower and as tall as the stamens. In a flower from which the sepals and petals have fallen, it is even longer than the stamens. Finally, the very threads wither, but still the pistil grows on.

**Really a seed case.**

If the swollen base of the pistil be held up to the light, it will be found full of specks which fall away if pricked. Let the children call to mind a pea-pod. These specks are seeds just as the peas are, and the pistil therefore is a seed case like the pod. A ripe specimen will disclose whether the seeds are contained in separate divisions of the cavity, and whether they are attached in any way, or just loose beads in a box. Here is a new puzzle. How do the ripe seeds escape out of their tight little prison? The walls harden and stiffen and at last they split, frizzle and curl upwards. They hang, at last, by their tips only to a dividing membrane of the seed case. The seeds remain hanging by their stalks to this membrane for a short time. Then the stalks also shrivel and wither like palsied fingers, which are powerless to hold anything any more, and the seeds drop to the ground one by one.

Thus we see that the innermost, sheltered treasure of the flower has been all along this caseful of seeds. The forked spike has long since withered, wall and seed has fallen, and only a few naked membranes remain at the ends of the withered flower stalks.

Good bye, dear wallflowers, till next year!

**Summary.**—The pistil is the central and most protected part of a flower. It is really a seed case, and, while it swells, the other parts of the flower gradually fall away and perish. When the seeds are ripe, the seed case splits upwards to liberate them, and then falls away in its turn.

**Art.**—Some of the petals drawn with the brush in the last lesson should be enclosed with straight lines. They make a

triangle. Put four triangles together and they form a square. Wallflower blossoms drawn or painted into squares will impress a child's memory with the leading characteristic of the cross worts, and form an agreeable diaper pattern. The linear leaves and seed-vessels might take the place of straight lines in the formation of simple patterns.

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# 9.—THE SINGLE TULIP FLOWER.

(*FIRST WEEK IN MAY.*)

**The parts of a flower compose circlets one within another.**

There is no flower that blows but wears several crowns, or circlets, placed tightly one within another on the round flattened head of the stalk. Some are very modest about it, but the tulip wears three boldly and openly. We will take them off one by one. First a circlet of three petals. Then another gorgeous circlet of three more flaming petals, and inside these again is one of six stamens. Lastly comes the pistil, composed of a single piece you will say, and no crown at all. Perhaps the tulip was punished for assuming such a boastful look by the fourth circlet getting spoilt. All the pieces may have stuck together. Wait and see.

**Sepals and petals share dress and duty.**

How did the sepals differ from the petals in the wallflower? In the tulip we find six leaves which are equally strong to labour and equally gay to please. They all start life as green as the foliage leaves:—the outer three remain so longest, but finally they don the same bright colours as the inner three. In fact petals and sepals are alike, which may denote that they have one and the same duty to perform. We found that the work of the wallflower sepals was to protect the inner parts of the flower, and in this the petals helped them by roofing over all crevices and by filling up all gaps so that no

draught could blow through the flower. But why should not wallflower petals be as tough and brown if they have only to do the same work? Or why should the tulip's outside leaves take the same colour as the inner leaves, if not to help them in the performance of some task for which bright colours are needed? These questions may convince us that we do not yet know what, in particular, the petals have to do; and indeed it is an exciting discovery that lies in store.

**Six Stamens: Their dust is called "pollen."**

Meanwhile let sepals and petals be picked off. Very likely the stamens come away with them—for there is one attached to the top of the flower stalk just inside the base of each leaf. How many, therefore, are there? (6). The stamens look like candles with extinguishers on, and each curiously-shaped dust bag can be drawn off the slender wick-like tip of the thread. It splits down the outer sides when the yellow dust is ready to shower out. This dust is called "pollen"—a foreign word meaning "dust," just as stamen means "thread." We have still to discover the use of pollen, as also the work of petals.

**Pistil three-lobed and its seedcase three-celled.**

We find at last a central spike, and though it is much stouter and stronger than the one we saw in the wallflower, we guess it must be the pistil. It can support the heaviest bee that lights on it without flinching. It has, moreover, funny looking double frills curling over its tip, which is three-lobed instead of forked. What *can* the frills be for? Another question to be answered later. We can make sure that this spike serves the same purpose as the wallflower pistil by cutting it across. We shall find it full of little tiny seeds, and we know that the nature of a pistil is to be a seed case.

**The circular flower plan is arranged by number.**

The seed case is partitioned off into three little rooms. Now imagine if, instead of sharing walls, each room were quite separate and detached, then the pistil would form a circlet of parts, just as petals and stamens do.* But Nature

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* It will be best to omit all suggestions concerning the morphology of the pistil unless monstrous tulips or ordinary members of the Ranunculus family are obtainable for illustration.

evidently thought the tulip wore crowns enough, and the pistil is all plastered up and transformed into one tight little column.

We can generally make sure there will be as many divisions beneath as there are forks or lobes above in the tip of the pistil.

Altogether, then, the tulip has six coloured leaves, six stamens, and three divisions or "cells" in the seed case. The wallflower has four sepals, four petals, six stamens, and two divisions in its seed case (for the pistil was forked).

A flower has usually the same number of members—or a multiple of the same number—in each of its circlets.

It is interesting to draw these circlets in the form of a diagram or plan, *e.g.* to show what a symmetrical and beautiful arrangement of parts pertains to every flower. Every part, with unfailing regularity, occupies the appointed place on the expanded head of the flower stalk.

**Importance of characteristic number.**

Though it is not likely that any one would mistake the wallflower for the tulip, we have now found that apart from outward dissimilarity they are both made up of similar parts. What, then, would the children guess to be the most important distinction between these two flowers? The colour is different, but then tulips and wallflowers are both very variable in this respect. The size is unlike; but one sometimes sees very tiny tulips and very fine wallflowers. Again, the shape of the petals, etc., is different in the two kinds; but shape, like colour, varies even within the limits of the same kind of plant. We want to find a difference between wallflowers and tulips which will always hold good. Now if children were to count the parts in however many single tulips, they will always find the number to be based on three, whereas the number of parts in the wallflower is always based on two.

**Double tulips** (only if obtainable; second-rate sports preferred).

What do we mean by a double flower? One which has doubled its numbers or which wears at least one crown more than its single neighbour. Let the children think of

all the double flowers they know, and consider whether they ever find them growing wild. They will remember that double flowers are only to be found in gardens, though many have wild relatives. They are not *natural* flowers. The double tulip not only shows an unnatural number of petals, but its stamens and even pistil often seem to be more like petals than anything else. We find a petal-like flap instead of a pollen bag, or a petal with an empty pollen bag somewhere on its edge. No two double flowers are quite uniform in this respect, and it is therefore evident that such differences are of no value in comparing different kinds of flowers.

**Summary.**—The parts of a flower are grouped in circlets on the expanded top of the flower stalk. The tulip has a ground plan based on the number three, a more important characteristic than size, colour, or even form, as these points are subject to variation even within the species.

Double flowers are artificial products of gardens, and are unreliable for comparisons. The double tulip grows petal-like stamens and pistils.

**Drawing.**—Careful outline, on very large scale, of petal, stamen, and pistil. A mastery of parts preparatory to design. Complete flowers and leaves may then be broadly outlined in chalk or charcoal as a guide to ultimate design. Haite's "Study of the White Lily" will be found a useful example of bold line treatment.

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## 10.—TULIP LEAVES.

(*SECOND WEEK IN MAY.*)

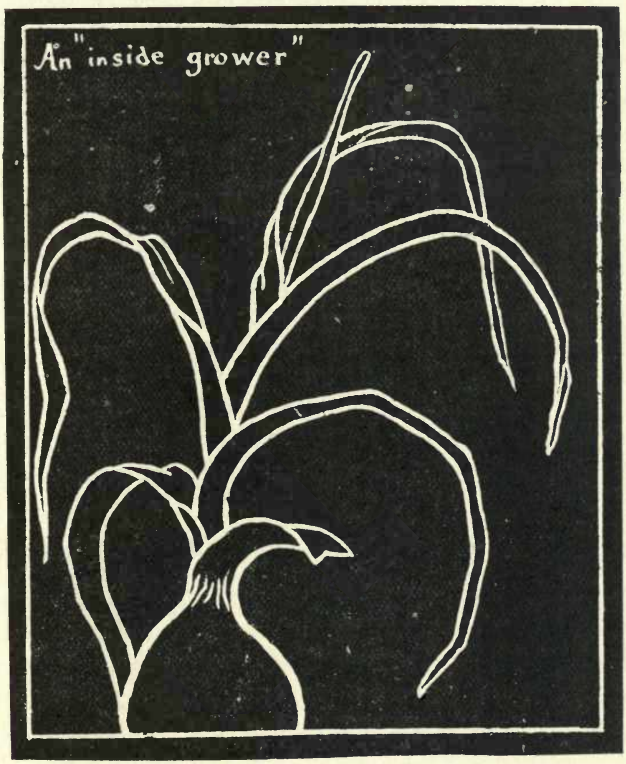
**Wallflower and tulip leaves compared.**

On comparing the flowers of the wallflower and the tulip, what did the children discover to be the most important distinction, and why was it the most important? Having recapitulated this point, let them next compare the leaves of the plant in order to try and discover equally important contrasts. The size, again, is of no account for it will be

noticed that the upper leaves of the tulip stem are often almost of the size of a wallflower leaf, and not unlike it moreover in shape.

**Tulip leaves are parallel veined.**

Let the teacher draw a wallflower leaf on the blackboard, veins and all; also the outline of a tulip leaf. The children may then hold up their leaves to the light so as to see the veining, and tell the teacher how it must be drawn. They will discover parallel instead of netted venation. This, then, is




the first distinction, and as it always holds good it is an important one.

**And sheathe the stem.**

It is not very easy to strip the leaves off a tulip stem, for they do not break away, leaving a clean scar like those of the

wallflower. They tear off at a ragged edge instead. Here is a second distinction. The tulip leaf, like the grass blade, sheathes the stem. At the base it joins the stem all *the way round*, and only very gradually can it leave this tubular shape and flatten itself into a blade. (Remember the difficulties we had over the paper model of the grass blade.)

**And hide no buds in their leaves.**

Wherein does an exposed tulip stem differ from that of a wallflower? The latter branches, but the tulip does not. It has no buds in the joints of its leaves, from which branches could grow. It has only a terminal bud; and as this is a flower bud, the tulip can only grow by lengthening the spaces between the leaves. Let it be noticed how the leaves wrap each other up before the stem lengthens out. The youngest is in the middle enclosing the baby flower bud—the most precious part of the whole plant, as the seed is of the flower itself.

Thus the tulip has one only bud, and that is a flower bud, so we can only conclude that it is an inside grower. When we examined the bare twigs of outside growers, we found that each leaf scar had a bud above it, which grew in the joint of the leaf before the latter fell.

We have then discovered a third distinction between the wallflower and the tulip. Next we come to a fourth (which we promised some time ago) in connection with the flower.

**Inside growers have their flower numbers based on 3.**

All the parts of a tulip flower count three or three multiplied. This is the rule of inside growers, instead of the two, fours, or fives of outside growers.

Diagram showing position of crowns in flower of inside grower. (Le Maout.)

**Conduct of water to the roots.**

One more observation on tulip leaves: let the children pour water over a plant to see what happens when it rains. If they pour only a little water the leaves remain in an upright position, so that the drops run down to their hollowed base. Here it collects till

the cup is full, and then overflows from leaf to leaf till it at last reaches the ground close to the bottom of the stem. The leaves, in fact, have guided the water to the roots of the plant. But a plant can have too much water, just as a human being can have too much food; and if it rains very hard the leaves get beaten backwards so that their tips hang downwards and outwards. Thus, in the end, half the water is carried away from the roots. What a far-seeing mother Dame Nature is!

**Summary.**—The tulip proves itself to be an inside grower by having (1) flower parts arranged in circlets of three; (2) leaves straight veined; (3) leaves jointed to the stem all the way round and without buds at the joints.

Tulip leaves serve to conduct water to the roots, or *vice versa*, away from them if the fall is heavy.

**Art.**—Separate petals to be simply expressed with the brush. Afterwards entire flowers and leaves if time permits.

These are colour studies preparatory to design.

## 11.—TULIP BULBS.

(*THIRD WEEK IN MAY.*)

**Roots feed the plant and fix it.**

In this lesson the children must learn that a bulb is a stem and not the root which they probably take it for. First, let them understand what a root really is and does. It has two functions. If we remember the disasters that happen when we accidentally cut the roots of a plant, we shall get at one function, viz., to procure food for the plant out of the ground. Secondly, let the children say why young trees are staked when first planted. Roots perform the same function as stakes; they prevent the wind blowing the plant over by holding it firm in its place. So the root is both feeding bottle and anchor. These seem incongruous things, yet nature makes a single apparatus serve the ends of both.

**Roots grow down and stems up.**

Roots, then, have special things to do, and must grow therefore in a special way. If a plant be set in the ground upside down, root and crop will perish—neither can live in its own special way. Cut off a twig and plant it lower end up—the buds will turn round, peering skywards. Crop *will* grow *up;* roots *must* grow *down:* this is the special distinction of each.

**Stems bear leaves. Roots do not.**

Another distinction is that roots never bear leaves. The children may now be able to find out what a bulb really is—whether it belongs to the root or to the stem.

**The bulb is composed of fleshy white coats or scales.**

First, let us pick one to pieces. Like the Chinaman in cold weather, it wears innumerable coats, one over another. At first we take the bulb to be just a poor beggar with coverings all ragged and brown; but these are only a disguise—those within being of a beautiful clean ivory colour. Each coat completely covers the one next underneath it. The innermost are the thickest and most substantial. The flower stalk springs from within the central coat of all.

**Coats, buds and flower stem grow on a flattened centrepiece.**

At the base of some of the inner coats may be found bud-like knobs. We shall pry into their real nature directly. The whole bulb originates from a flat solid centrepiece of which the flower stalk seems to be a continuation above; below, it sends out rootlets, and perhaps it is itself part of the root?

**The coats are undeveloped leaves.**

In some kinds of bulb, the coats do not entirely cover one another but only overlap like bud-scales, which they largely resemble; indeed, they are actually called "scales." Can any child guess what they really are? If possible let a young tulip bulb, which has only put out a single leaf and no flower,

be examined. If the leaf is traced to its origin, the base will be found white and fleshy and exactly like the coats of the bulb outside it. In fact it started life as one of these—only it had more ambition, and it grew while the others did not. The coats or scales of a bud are underground leaves, therefore it will not be surprising if we find that they put out real buds at their joints.

**The flat centre is the shortened stem.**

If, then, the scales are leaves, what is the flat centre-piece? What but a very much shortened, thickened stem, like what we find in the centre of any bud formed on a tree or shrub, only on a very large scale. It never lengthens out between the leaves it gives off, but puts out a central terminal bud which grows into the flowering shoot. In the young tulip plant we found this central bud asleep inside the central leaf. It will wake up another year.

Onion bulbs may be compared with tulip bulbs as they are of the same character. If time permits, the children may be told about "top onions" which are often produced in flower clusters instead of blossoms. They are buds composed in the same way as underground bulbs, and they finally *drop* off to form the bulbs of fresh plants. They are sometimes called "bulbils," and are an example of the kinship between bulbs and buds. The bulb is like a permanent bud underground.

**Increase of bulbs.**

The leaves and stem of the tulip wither away very soon once the seeds have been scattered, but a new central bud is ready within the bulb to form next year's flowering shoot. And what about the other buds which we saw at the base of some of the inner bulb scales? If we pick one of them to pieces we find it is like a small edition of the big bulb—in fact a "bulbil" again. It will put out roots of its own, and in the course of two or three years, grow into bulbs like the parent. Have the children never seen these families of bulbs—large and small clumped together—dug out of the ground where they had been left undisturbed for years?

Let stress be laid on this mode of increase in bulbs. Plants do not like to have to depend solely on seeds. We

shall find presently that they have got yet other ways of keeping on in the world.

**Summary.**—The business of roots is to feed the plant and secure it in its place. They may be distinguished from stems by the fact that they grow downwards and do not give off leaves or buds. Bulbs are made up of thick fleshy leaves growing underground from a very much shortened and thickened stem. Bulbils are sometimes formed above ground, and oftener in the cradles of the bulb scales.

**Drawing.**—Big broad studies of various bulbs may be drawn in chalk or charcoal outline, and also of any such young growths as suggest the nature of bulbs. Martagon lilies and Crown Imperials, when they first sprout, have a very much compressed stem, thickly set with leaves, suggestive of green-growing bulbs above ground. (Bulbils are often found later on in the axils of lily leaves.)

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## 12.—FUNCTION OF BULBS.

(*FOURTH WEEK IN MAY.*)

**Difference between underground and overground leaves.**

We found in the last lesson that the tulip plant has two very different looking kinds of leaves. (1) They differ in position, for one kind spends its life underground, growing round a stumpy stem; and the other grows above ground from a yearly shoot given out by the underground stem. (2) They differ in colour, for the underground leaves have pale white faces—as children would that lived in cellars. Even the flower stem is white in its underground part, so we may conclude that green colour is caused by sunlight. (3) They differ in size and shape, for the underground leaves do not grow out into a flat blade like the upper leaves. (4) They differ in thickness, for the bulb coats are fat and juicy. It is easy to guess that

these leaves must have two different kinds of work to do in life.

**The bulb "scales" are store-rooms.**

We saw that the outermost coverings of the bulb were dry and brown, and that the white coats inside them were less fleshy than the more central ones. It is not difficult to guess that the brown coverings are withered up coats of the bulb, and that the inside coats will some day be so too. If we had dug up this bulb last autumn the outer coats would have been found as juicy as at present the inner coats are; and that what is now a flowering shoot would then have been found to be a bud similar in appearance to what we saw wrapped up by the young tulip leaf. If we had dug it up earlier in the spring, we should have found that no change had as yet set in; for bulbs, like tree buds, rest during the winter, having during the previous season of growth completed their preparations for starting growth when favourable circumstance presents itself. All that happens during the course of early spring is the drying up of the outer coats and the growth of the terminal bud into a leafy flowering stem. Just so; but this rapid latter growth sets in while the ground is still too hard and cold and dry for the roots to work in it. Wherever then does the necessary food come from? Where, but from the plant's own store-rooms—the great fat underground leaves? Now we know why they shrivel as the plant gets older and sucks away their contents.

**Stems of trees are also store-rooms.**

The buds of the trees around are swelling and bursting—they, too, could not grow so quickly if they had not store rooms to supply them. In their case the food is put away in stems, as we shall presently see.

**The green leaves are the kitchens of the plant.**

These store-rooms, both bulb scales and tree stems, were ready last autumn; they must have been stocked during last summer. Where did the supplies come from? We know that the work of the roots is to obtain food for the plant out of the soil, but they have not got all the work to do. If we

were to pull all the leaves off a plant as fast as it grew it would soon die. This is how the plant gets fed :—the roots provide the raw food materials from the soil, and these pass inwards through the stem till they reach the green leaves. The leaves, meanwhile, absorb other raw materials from the air, and these are worked up with the supply from the roots and changed into food which the plant can digest. The leaves, in fact, are the kitchens of the plant where the raw food is cooked by sun-heat. When it is ready it travels back into the stem and feeds the new buds which are forming. The withering of the leaf takes place when *all* the food finally leaves the leaf to lodge in the stem, or in the case of bulbous plants, to be stored away in the bulb scales. Thus it is that buds are able to open and grow at such a pace; the young leaves, like little children, are relieved of the necessity to provide the food for their growth when they start life. This is what we meant when we talked in the first chapter of the buds being born to an inheritance. Their task, on the other hand, is to maintain and further the life of the tree or plant. How it is all done, and especially how the food ascends through stem to leaf and back again, constitutes one of the great interests and mysteries of science. Perhaps when we are older we shall know more about it. Whether it will ever be quite understood is another matter.*

**Foliage leaves feed their buds and scales their bulbils.**

We can perceive, better than ever now, why, in summer, the centremost buds on a tree are the largest. It is here they enjoy most air and sunlight for the getting and cooking of their food supply; and their own special buds are bigger than any others. Just as leaves feed their own buds, so bulb scales at first feed their own bulbils. After a while the bulbil grows roots and puts out a single leaf. Thus it collects supplies, and by the third year may have enough to afford a flowering shoot.

**Bulbs need not await warm weather.**

Let the children think of all the flowers they know which lead the way in spring. By far the majority of the plants

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* The foregoing physiological allusions are mere appeals to the child's imagination for the sake of stimulating curiosity and study in after years. The whole matter is too difficult, and involves too much special apparatus (microscope, etc.), to be treated seriously here.

are bulbous. Those that have not got equally convenient store rooms have to wait for warmer weather. Roots cannot do their work well when the ground is hard and dry.

**Summary.**—The leaves of plants absorb food materials from the air and mix these with food materials sent up to them through the stem from the roots, so that the plant can digest what it requires, and store the rest in stems or bud scales to facilitate rapid spring growth.

**Art.**—A design may be made embodying previous studies of the tulip. The whole plant, including the bulb, admits of highly decorative treatment. As a stiff border, involving rapid repetitions, it will not greatly tax a young designer's imagination.

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## 13.—MELON LEAVES AND TENDRILS (1).

(*FIRST WEEK IN JUNE.*)

[The vegetable marrow, cucumber, and melon are all nearly related, and any one of them will serve for this lesson. The teacher will readily notice any small distinctions.]

**Tendrils necessitated by weakness of stem.**

Why should a melon plant sprawl in such a lazy way over its hot-bed? Why is it not upright and independent in its growth like the wallflower? Perhaps it is all the fault of circumstance, and we could straighten the back of our melon by setting it in a favourable position to start life. But no, its stems flop down again and lie on the ground. They are thick-set enough, but they are also too soft and fleshy to carry their own weight, let alone that of the big heavy leaves—and so somebody else must support it for them.

What other clinging plants can the children remember for comparison? Some kinds of roses grow tall, weak-backed stems, and need a wall to rest on; but they do not hold on to their support for themselves as a melon plant does. Only try to pull it from where it is lying and see how we are checked!

Everything seems to be in the clutch of long green fingers which coil up corkscrew-wise (*cf.* also the mainspring of a watch). They stretch out when we pull, only to coil up again when we let go. Notice how these "tendrils" curl up on themselves in the bud—then, next, how they uncurl, beginning with the middle finger, and feel after something to catch hold of with their hooked tips. When a tendril once gets a support within clutch it coils securely round and round to such an extent that the parent shoot is dragged further along. If we were so to twist an ordinary stalk or stem it would tear and break. An interesting problem for the class to study is why the melon tendril should be able to bear this strain. A solution will be found by those who observe the half-way change of direction in each coil.

**The coverings of leaf and stem.**

We find the young marrow leaves are soft and velvety, whereas sharp prickles on the older leaves and stems give the order "hands off," which we quickly obey. We must have noticed in the preceding lessons how every trifle means something more or less important to the plants' well-being; so here we are met by another problem: what purpose do the prickles serve? Perhaps it will occur to some that it is a very good thing for the melon plant, if we are afraid of picking its leaves—we saw in the last lesson how useful they are. And in truth prickles ward off all kinds of vegetarians. But for them, gorse and many another plant might have been exterminated ere now by grazing animals.

Next, let us discover why the youthful growth is soft to the touch, and we shall find that the hair has not yet hardened into prickles, or is only on its way to doing so. We find every intermediate stage on various portions of the plant, the baby leaves being set with veritable down.

Perhaps some of the children will think it is very hard that the babies should be thus defenceless, but let us see how the soft down may perhaps fulfil purposes in which the formidable prickles would fail. Look at the plant after a shower or after the morning dew—how is it that the moisture remains on it so long when other plants are already almost dry? The tiny drops are caught and entangled in the hairs. The leaves thus make the most of the rain, but at the same time they are

protected from too much moisture and wettings. The hairs are so close together that they will only let a limited quantity pass. Thus the tender babies are after all safe against two of the worst enemies that could assail them, *e.g.* cold and drought. One and the same means protect them against too much wet and against too little. At the same time, these babies often nestle amongst the older growth, and are tolerably sheltered from browsers.

**Arrangement and shape of leaves.**

Let the children recapitulate what they learnt about the arrangement of leaves in lesson 3, and then try to trace the order of these melon leaves. By the way, their buds seem to have slipped out of the cradles—due to the twisting of the stems, say some. Other botanists surmise that possibly each bud belongs to the leaf just above it, and is really in its proper place at the base of a long stalk which is growing against the main stem in order to buttress the latter. (N.B.—Would an artificial buttress of human device cause

these leaf stalks to start free growth from the bud upwards? Selected plants and accidental variations should be observed.) If we were to try and describe a melon leaf we should feel puzzled, for no two are exactly alike. There is a reason for

this variety, as for everything in nature, and perhaps some day the children may find out what it is.

Further: not only has each leaf a peculiar shape, but each has a peculiar stalk of its own. The veins of the leaves stand out like ridges on their under side, each of the main veins ending in a point of one of the leaf divisions. The leaves of the wallflower were similarly "net veined," but a single main rib ran to a single point, thus reminding one of the long, narrow, straight-veined leaves of inside growers. A broad shape and a much divided edge such as we see in the melon leaves, is more strictly characteristic of the outside growers to which our plant belongs.

**Summary.**—The melon plant is an outside grower, and clings to its support by means of tendrils. It is downy at first, and then the hair serves new protective purposes by hardening into bristles.

**Drawing.**—Bold outline in charcoal on a large scale of leaves and tendrils, of melon, cucumber, vegetable marrow or bryony. Guide to ultimate design. (See Haité, p. 70, for an exemplary study of bryony.)

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## 14.—THE MELON FLOWER (2).

(*SECOND WEEK IN JUNE.*)

**Size unlike. Sepals and petals alike in number and unity.**

What makes the melon flower so showy that we cannot help seeing it at once among the great green leaves? There are two causes, you will say—its bright yellow petals and its large size. But some, you add, are half the size of others. Can this be just by chance? Wait awhile, and meanwhile see if the flowers differ in any other way.

All have an outer circle of five sepals; and what a contrast it is to the petal-like sepals of the tulip, or even the wallflower

brownies! These soft, green spikes surely never sheltered such large blossoms! But look at a bud. Behold the hairs which fringe the sepals unite to screen the baby flower!

We cannot detach these sepals separately like those of either the wallflower or the tulip. They join together half way down and form a tube. The petals do the same, and we might take them for just one big leaf topped by five divisions. In this respect, then, we have quite a different type of flowers to those previously studied.

### Protective petal ribs.

Is there a point of resemblance between these petals and the foliage leaves? Yes, for we see that the leaves are built on a framework of veins, and each point of the yellow blade marks the central lines of a similar scaffolding. If we hold the membrane lightwards we see the same complicated network that we noticed in the leaves, and the delicate yellow tissue is stretched between it just as was the green blade.

If we pull a bud to pieces we will find this delicate tissue folded on itself, while the strong hairy veins project on the exterior. Young leaves are folded in the same defensive manner.

The sepals are arranged alternately with the petals, as in other flowers which we have examined. When the bud begins to open they cover the thereby exposed portion of the petals between the central veins.

### Stamens and pistil occupy different flowers.

What do we expect to find when we look down into the beautiful cup of petals? A circle of stamens, you will answer, with the pistil in the centre. Sometimes we do indeed see a dusty yellow heap of pollen bags, but elsewhere there are only three slimy-headed central parts, which shed no pollen, and must therefore belong to the pistil.

### The stamen flowers.

These are all the small blossoms. The stamens form a cone by joining at their tips, and thus they roof over a saucer-shaped hollow in the middle of the flower. It is a very slimy saucer, for it is all honey-smeared. Which child remembers where the wallflower stored its honey? In the middle of the

saucer may be seen a little point—all there is of the poor little pistil which has never grown any further.

Are there only three stamens? The children should know what number, or the multiple of what number to expect, after counting the other parts of the flower; and they will look, in spite of appearances, for five. And sure enough they will find that two pairs (sometimes one only) are joined along their whole length.

**The fruitful flowers.**

These are the large blossoms. Very rarely they contain stamens. Nearly always they are undeveloped, and the pistil stands by itself in the middle of the saucer, with honey all around. Thus the melon has two kinds of flowers, each containing organs which, in both wallflower and tulip, we found present in a single blossom.

The pistil has three branches (as the tulip), each subdivided twice and slimy to the touch. There is no deception about these three branches as there was about the number of stamens; and three are constantly present in both cucumber and vegetable marrow. In the melon alone, however, we find a frequent reversion to the ideal five. In the case of both wallflower and tulip the seed-case part of the pistil grew inside the flower-cup, and was therefore "superior" in origin to the floral circles. But where is the melon's seed-case? We look for it in vain within, and at last find it below or "inferior" to the flower and separated from it by a narrow neck.

**Edible seed cases.**

If this great seed-case swells as fast as that of the wallflower did, we must expect it to grow into something very large indeed. We may surmise what is coming if we know why gardeners grow these plants at all. A confusion may, perhaps, arise here in the minds of some of the pupils. They are accustomed to think of the melon as a fruit, and of cucumbers and marrows as vegetables—yet both are full grown seed-cases. In fact, a fruit is nothing but a seed-case along with any part of the stalk which may have swollen also. If we cut the young melon or cucumber across we can see little white dots, which are the baby seeds. When they are

ripe the total seed-case or fruit has reached its full size and is fit to eat.

**Summary.**—The melon family contains stamens and pistil in different flowers. Those containing stamens are smallest. Sepals and petals join at their base, and two pairs of stamens are also often united. All these points constitute a great difference between these and the flowers previously studied. The petals are veined and hairy like the foliage leaves.

**Drawing.**—An outline in charcoal of melon, cucumber or vegetable marrow flowers; entire, and, also, of the parts. Guide to ultimate design.

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# 15.—MELON (3).

## Cross Fertilization by Insects.

(*THIRD WEEK IN JUNE.*)

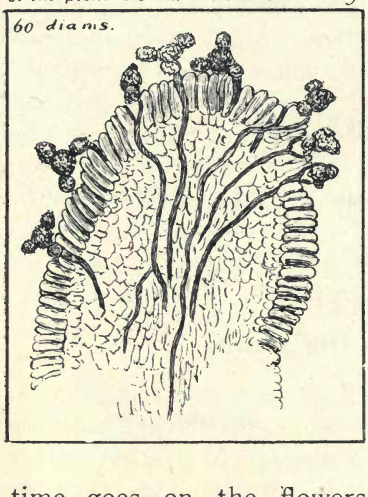
**Stamen flowers necessary to the plant.**

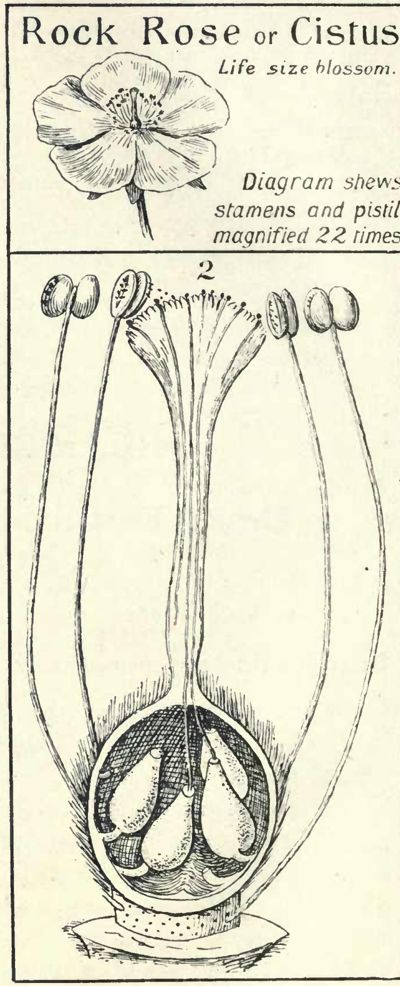
We have seen that the pistil flowers are fruitful, but that when the stamen flowers wither they leave nothing behind them. Experience has already taught us that nature has a purpose, an aim in view in all she does, and we must set to work and find out why the melon flowers differ in the internal arrangements from other flowers we have observed. Supposing we were to cut off these seemingly useless flowers as soon as they opened. What do the children think would happen? The pistil flowers would bloom on as usual, and seem just the same till withering time came, and then we should find that the baby cucumbers were not growing, and the seeds inside were not swelling. Before long they would shrivel away like the petals.

**Pistil tips need pollen for the seeds to ripen.**

The stamen flowers then must somehow affect those with pistils. Imagine we try the following experiment. Let us shake some of the pollen into a piece of paper, and on a fine morning, when the sun is out, sprinkle the sticky pistil tips with it. Lest insects should interfere we shall cap every single flower with a gauze bonnet, through which sun and air alone may penetrate. Now watch and see. As time goes on the flowers wither, but the seed cases of those which we have dusted with pollen alone do not perish, and in time their seeds ripen. This fact, we have now found out for ourselves, must be due to the pollen, and we see why the pistil tips become conveniently sticky at the very moment when the pollen bags burst.

*Some 3 cornered pollen grains of an evening primrose sending out feeding tubes to the seeds through the cellular tissue of the pistil Not all will find their way.*



**Fertilization effected by growth of pollen grains.**

But how can this yellow dust on the pistil heads make any difference to the seeds which are often a very long way off beneath a long pistil stalk? In truth, the tiny pollen grains are not the lifeless dust they seem—they can grow like any other part of the plant. Each sends out an invisibly fine shoot which pierces its way right down through the pistil tissue till it reaches the seed vessel. Here each seed has a tiny mouth open ready to receive the pollen shoot, which shall enable it to grow. (See diagrammatic pistil-section of rock-rose.)

**Insects are the flowers' messengers.**

But how can the pollen ever reach the pistil tip in the case of our melon flower? Just now we ourselves were the bearers of the pollen—can somebody suggest who might have carried the pollen to the flower if we had never interfered? If we consider why we should have gone to the trouble of covering the flowers with gauze bonnets just now, we may learn a great secret—flowers make use of insects as their pollen-bearers.

**Honey and pollen bribes.**

But why should insects thus serve the flowers? Do butterflies and moths and bees work without wages? Get at the answer by thinking why bees are hired by us. Ah! The flowers bribe with honey, and not only honey, but pollen too, sometimes. It helps to make the comb. Examine a dead bee and see the curved tuft of hair on the hind leg. Then watch the live bees among the flowers and learn the use of this tuft—it is the basket which carries yellow lumps of pollen for their use at home.

**Fertilization of the melon flowers.**

Watch how a bee settles on the central cone of a stamen flower. There it hangs head downwards and thrusts his head into one of the little apertures left on either side of the free stamen, in order to lap nectar off the central saucer. Meanwhile his hairy body is rubbing against the pollen and getting well dusted by it.

Next, let all eyes watch how he settles on one of the fruitful flowers. The branched pistil-heads offer him a steady

resting-place (*cf.* the stout pistil of the tulip) and he clings to these by his hind legs while he laps the honey around. The pollen grains are caught by the sticky pistil tips, and the deed is done!

**Bees visit only one kind of flower at a time.**

If we could follow the bee on its visiting rounds, we would find him confining all his attention to the brother and sisters of one kind of flower only, no matter how many other sorts might be in the neighbourhood. This is the way of bees, and it secures flowers against ineffective foreign pollen.

**Interdependence of flowers and insects.**

We now see that flowers and insects could not get on without each other at all. Many flowers could never "fertilize" their seeds but for insects, and many insects depend on nectar for food. But we shall presently learn that these are not the only ways in which flowers and insects help each other.

**Summary.**—Pollen makes seeds "fertile," that is to say, enables them to ripen, and in time to produce new plants. When stamens and pistil are in different flowers, insects carry the pollen from one to the other in return for honey, or a "basketful" of the pollen. They visit only one kind of flower at a time.

**Art.**—Colour previous studies with water colour or chalk, or else make brushwork attempts at flower, leaf and young fruit.

# 16.

# SELF-FERTILIZATION OF FLOWERS.

(*FOURTH WEEK IN JUNE.*)

**Complete flowers commonest.**

We have seen that the melon has pistil and stamens on different flowers, and that fertilization has to be effected by insects. But by far the greater number of plants produce flowers with stamens and pistil complete. Such flowers, then, let us call "complete flowers."

**Self-fertilization possible according to relative position of parts, etc.**

Now, are insects necessary to complete flowers, or can they fertilize themselves? This depends on whether the stamens are in such a position that their pollen can fall on to the ripe pistil tip—in other words, the stamens must be taller than the pistil, or *vice versâ* if the flower is pendulous. Or else stamens and pistil tip may be at such close quarters as to touch each other.

**Flowers prefer cross fertilization.**

What child can tell which is likely to be the wallflower's plan? Who remembers that the stamens overtop the pistil at first—though it overtops *them* finally? If self-fertilization then is possible, why should the wallflower produce nectar? There are many flowers that lay traps to obtain a neighbour's pollen, even when, like the wallflower, they can make use of their own. We conclude, then, that for some reason they prefer cross fertilization.

**Cross fertilization produces stronger seeds than self-fertilization.**

But we cannot make sure without experiment. Let us fertilize a flower with its own pollen; that is to say, let us sprinkle some of its pollen on its pistil tips, taking care that

no insect has already been at work. Next, let us cut off a neighbour's stamens before they ripen, and fertilize the pistil with pollen from another flower of the same kind. In time we must save the seeds which result and sow them. I think we shall find that those from the cross fertilized flowers produce the strongest, healthiest plants. Cross fertilization will then be proved advantageous to the plant.

**Devices of flowers to escape self-fertilization.**

Many complete flowers go to great trouble in order to escape self-fertilization. Perhaps some of us may tell without being told, how a plant may be able to prevent pollen from its own stamens reaching the pistil tip ?

First, it is by arranging their respective heights on just the opposite plans to those which we have described. Secondly, by the pistil ripening before or after the pollen bags burst.

**Colour and perfume attract insects.**

Lazy flowers which are content to fertilize themselves naturally do not produce nectar, and the bee does not trouble about them. How does he know where to go, and why could he find out melon flowers so easily ? If they had been small and dull coloured, like many lazy flowers, we might have had to search a long time. But size and colour attract an insect's eye as they do ours. In fact, honeyed flowers advertise the feast by flaunting petals which may act as signal flags.

Thus we arrive at the special purpose of petals, though, as we have seen before, they assist the sepals to do other work besides; and sometimes the sepals return the compliment (give a recent instance, e.g. the tulip) by putting on bright colours and helping the petals. The children may remember that the fruitful flowers of the melon used the biggest signals. It is better, for reasons they may explain, that many pistil flowers and only a few stamen flowers should be visited, than the reverse case.

When once the seeds have been fertilized, petals, stamens, and usually sepals drop—their work is done. Who can think of yet another insect signal ? Pale or retiring flowers may prosper as well as their more gaudy neighbours, by means of scent.

Strange to say, if they are grown under glass they often lose it entirely. Think of forced violets. Why should this be?

**Summary.**—Cross fertilization produces stronger seed than self-fertilization. Consequently, many complete flowers avoid self-fertilization by ripening stamens and pistil at different seasons, or by arranging them so that the pollen cannot reach the pistil. Colour and perfume act as signals to insects.

**Art.**—Design to be made in brushwork, and to be based on former studies of the melon plant.

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## 17. CORN. (1) Straw.

(*FIRST WEEK IN JULY.*)

**Straw requires to be strong.**

What an uninteresting subject! you may say. Well, let us study live straw while it grows, and see if we do not pass a different judgment afterwards. In the first place, what *is* live straw? The stalks of corn. How slender and fragile they are, compared to the thick melon stem which we have just studied! And yet how infinitely stronger, for feel the great weight of ear it has to support, and fancy the redoubled burden of the same when wet or weather-beaten! We have all seen the wind driving through the corn-fields, yet these stalks do not break, but merely bend before the onslaught. Slimness, then, does not necessarily mean a weak back, nor stoutness strength.

**Light because hollow.**

If we cut one across we find it is hollow, which explains why it is exceedingly light. The melon stem, too, is lighter than one might expect, being hollow also, only with much thicker walls.

**Hard because flinty.**

What is it, then, that causes the difference in strength between the two stems? Not only the degree of hollowness;

for if we squeeze the melon stem we find it soft and giving; and it splits along its length. The corn stem, on the other hand, though it gives between our fingers, is not bruised. The outside is as "hard as a stone," or as hard as a flint, which is a kind of stone. And indeed, straw is coated with a flint-like substance.

**Strength of Tubes.**

So we see that straw is strong because it is hard, but also because it is hollow.* In olden days when a very strong beam or pole was required—as for a ship's mast—one was made of solid oak. Since then man has discovered that hollow tubes of iron are both stronger and infinitely lighter. But plants made this discovery long before men did; doubtless you remember that leaf stalks are often grooved or hollowed. Let them be bent, and compare their elasticity with that of a solid round stem. The latter will be found liable to split, bruise, or snap. The hollow or hollowed stem gives all round the cavity and is therefore very elastic; and when, in addition, the walls are hard, great strength is obtained for the resistance of pressure.

We shall learn presently that these adaptations are not, however, *only* to enable the corn to hold up a proud head in the world. On the contrary, corn is but field grass—a modest thing which is content with little space and frugal food. Its elastic stem serves yet another and more important purpose which we shall learn by-and-by.

**Corn an inside grower.**

We said that the corn was a field grass. Satisfy yourselves that this is true by examining the straight veined leaves and their mode of growth with which one of our lessons must have already familiarized the class.† We said also that corn was a modest plant content with little space and frugal food. So spare is each plant's growth that it must make the most of what little moisture each gets. The points of the leaves are turned towards the sun—else, if their

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* Additional causes of strength are, of course, the nodes (most frequent where strength is most required, *e.g.* towards the base), and the enveloping sheathes of the leaves.

† If paper model as directed was constructed by the class.

blades were exposed to the rays of the summer sun they might not only interfere with each other, but dry up too readily. The children may remember the little membrane at the base of each leaf. It arrests water which might clog the interior of the plant—but it also diverts the drops, by pendulous "ears" towards the roots. Not a little trickle is wasted. What a lesson to careless gardeners who let whole rivers of water waste through leaky cans!

**Two kinds of inside growers.**

Let the children compare, say, a martagon lily with the corn. It has straight veined leaves, and its flowers are in circles of three, but the leaves are produced up the stem after the manner of outside growers. Fallen leaves, too, may be traced by a clean scar, and the flowers originate in buds at the joints of the leaves. Apparently the straight veining and the floral triplets are the only consistent characteristics.

Evidently our corn represents a different class of inside growers.

**Summary.**—Corn is a grass of which the hollow stem is a combination of great strength and elasticity. The lily represents another class of inside growers which shows a good deal of external resemblance to the outside growers.

**Art.**—Charcoal or brushwork study of reeds and grasses.

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## 18.—EARS OF CORN (2).

(*SECOND WEEK IN JULY.*)

**An ear of corn is a flower spike.**

What do we mean when we talk of an "ear of corn." Do we mean the part which contains the grain? What then is the grain? Seed is the obvious answer, and perhaps it will be time enough to give a more accurate explanation in the next lesson. Suffice it to point out here that if it is the seed,

the ear must be a flower or a cluster of many florets. In order to satisfy ourselves about this curious matter we will examine the ears of barley, wheat, and oats. The ear of barley, for instance, is composed of a great number of different parts, which are arranged singly up the sides of a common stalk and each of which contains "grain." Each, then, is or must have been a floret; and the ear represents a whole colony or "spike" of such florets. We hope to verify this in the next lesson.

**Compound spikes of wheat and oats.**

The wheat florets also grow along each side of a common stem; but they are arranged in groups, each group sharing a short stalk in common, and thus forming a branch "spikelet." This much ascertained, the oats' spikelet, which otherwise might be taken for a single floret, will not deceive us. But here a further complication arises. The oats' spikelets themselves form secondary ears (as it were), springing from the central stalk. A compound ear results with which many grass blossoms may be compared.*

**Growth limited by terminal flowers.**

If the corn were not cut but left undisturbed in the ground, why should it not grow and grow like Jack's beanstalk? An intelligent child may remember that there are no side buds—only a single terminal flower bud such as the tulip had; and it can grow no more, after blossoming, except by lengthening the stem between the leaves.

**Flowering is the plant's object in life.**

What, then, would happen to the corn if it were not cut? It would wither; and indeed the yellow colour is a sign that stem and leaves have accomplished their purpose and that the seeds are ripe. Do we mow the hay at an earlier or a later stage of grass life than that at which we cut the corn? Again, why do we mow hay when in blossom? Because it is at that period a far more nourishing food material than if left until a later stage. All the sap from the grass stalks would then pass into the ripening seeds and the crops

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* See illustration of couch grass, p. 179.

would turn yellow and wither like the corn. Once the seeds are scattered the rest of the plant dies—the aim and object, to flower and ripen the seed, is accomplished.

All through this lesson the children may have wondered why the ears of corn are called "flowers." The flowers of grasses and many others are not distinguished by colour; and they are not yet aware that a flower has a great deal more to do in life besides flaunting bright petals for man's pleasure. Call attention to the flowers we have studied before. Each part, but especially the sepals, helps to keep a little central nursery warm and dry—the petals attract insects and the stamens produce pollen, in order that the seeds may prosper. Here then we have it: a plant lives for its offspring.

**A flower essentially stamen or pistil only.**

Many flowers are without petals, and many more are without sepals. These parts are then helpful, but not necessary portions of a blossom. Supposing we had pulled the petals off the melon flowers, insects would not have been attracted. But supposing the insects had persevered in their search, seeds would in the end have been produced as usual. Further: the melon proved to us that stamens and pistil need not be contained in the same flower. A blossom reduced to the fewest possible number of parts may be said then to consist of stamens or of a pistil only. As these are indispensable to the production of seeds, one or other must be there in brother and sister flowers. This is the case in the Indian corn, and (to give quite a different example) in the "pussy willow," of which the flowers are only protected by a woolly scale.

**Summary.**—Ears of corn are really spikes of florets. A floret *need* only consist of a stamen or of a pistil, these being the parts necessary for the production of seeds which is the plant's purpose in life. (The consideration of relativity, the further purpose and object of the plant in the economy of nature must be excluded at this stage. All we have to do with here is the function of the plant as a living organism.)

**Art.**—Charcoal or brushwork studies of corn in flower and ear, also of the component parts of flower and ear, to be drawn larger than life. Compositions as guide to ultimate design.

# 19. CORN. (3) Chaff.

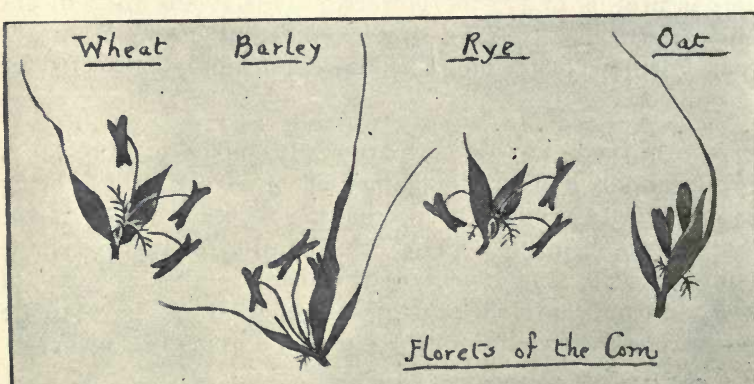
(*THIRD WEEK IN JULY.*)

**Spikelet of florets protected by chaffy bracts.**

What is chaff? The covering of the grain—separated from the latter when it is threshed. We always think of it as something very dry and very light. Examine a spikelet of oats. Do the husks (or chaffy part) belong to the floret (assuming, while we await explanation, that a floret is the part which has produced a grain)? There is a good reason for supposing that the two outer husks do not, for they enclose more than one floret—just as if they wished to put out their arms around the blossoms to take care of them. They are really foliage leaves which often seem influenced by the neighbourhood of flowers; so that they mimic the petals, dwindling to their shape and size, if not to their colour. They are then called "bracts." The two bracts which we are looking at now do not both start from the same level; a lower one overlaps an upper one. They are, in fact, placed alternately on the stem like real leaves.

**Three florets to a spikelet.**

How many florets go to form an oat spikelet? There are two containing grain, the smaller of which seems to grow out




from within the larger; and from within the smaller again, starts another stalk bearing only two tiny empty scales.

The spikelet is exhausted by the two grains and cannot let a third develop properly.

**Two bracts cover each floret.**

The husks which wrap up the grain resemble the two outer bracts closely, only they are smaller. Can they possibly be portions of a real floret? The base of one is lower than the other—another point of resemblance to the outer bracts—and sheathes the spikelet stalk. A real sepal or petal would not go out of its way to do this, and we recognize a third bract borne by the stalk of the spikelet. In its joint it puts out a small scale which is the last covering of the floret and its tiny stalk, and is consequently called a "flowering bract."

**Protective spine of the flowering bract.**

The husks probably reminds children of the boxes in the toy shops which fit closely one within another. Now we have reached the centre of the puzzle and our innermost bract hugs the grain. He humps his central rib, elongates it as a rule, indeed, into a long protruding spine, and thus seeks to keep hungry enemies away from his treasure.

**Petals represented by two tiny scales.**

Before pulling this rude guardian off his seat, let us look for two little scales—not always present, but great curiosities where they exist. They complete, along with the flowering bract, a circle of three. You remember, perhaps, that the florets of inside growers have their parts arranged in triplets. Well, we have been on the look out for petals all along. Perhaps here at last we have found material for them: but one was more energetic than the rest—it volunteered to do most of the work, and it was allowed to grow up alone. Not all the work, however. These little scales have a great gift for absorbing moisture which we shall learn the use of before long; the damp cold night makes them swell out like sponges, so that by morning time early the floret is thrust open for a short time. Then the little scales dry their wings and the floret closes again. The door is shut to insects, and indeed it seems as if the corn were quite indifferent to them. No honey is signalled by brightly-coloured petals.

**Three stamens and a hairy branched pistil.**

Between these scales and the flowering bract there are three slender stamens—take care, do not break them! The pollen bags hang on by their backs so as to sway lightly to and fro. There is a good reason for this to be learnt by and by. The pistil, instead of being sticky, grows branches which seem bent on catching the pollen grains in every direction—so long are they and very hairy. And now do not let us be deceived about the grain beneath—a seed indeed but a pistil case as well, thin as skin and so inseparable that when the seed falls the case is buried with it. We remember how the wallflower and tulip cases split to scatter their contents. But the plan of the corn is adopted by all single-seeded plants.

Perhaps we understand now how a grain of corn is as truly a "fruit" as the great fat melon or the giant marrow; and how the little pistil with its three stamens, a couple of scales and a flowering bract, is as truly a blossom as the dahlia or the sunflower.

We shall hope to solve many problems in the next lesson, and learn why our little corn floret is so eccentric.

**Summary.**—An oat floret consists of three stamens and a one-seeded pistil, protected by a flowering bract and its spine; it is further encased by three more bracts, the two outermost of which also envelope the total spikelet of two entire florets and one defective one. Petals are represented by small scales and sepals are always absent.

**Art.**—Brushwork studies of oats, including leaf, stem, flower spike and ripe ear.

# 20. CORN (4).

(*FOURTH WEEK IN JULY.*)

**The minute bracts and elongated spine of barley.**

In our last lesson we studied oats blossom very closely. We will now examine spikes of barley. The florets are arranged singly by the sides of the stem, and we may therefore be in doubt whether we shall find the two big bracts which took care of oats and wheat spikelets. But at the base of each flower are two tiny wisps. Perhaps these are the two bracts which have never properly developed because they were not needed. And why not? Look at the enormous spine of the flowering bract! It has required more than the central vein to form it. Thus the barley floret loses two protectors merely in order to gain a third. Compare the short spines on the outer bracts of wheat. Those of the flowering bracts are somewhat longer, especially among the spikelets towards the summit of the ear. But these spines are not a development of the central vein as in barley and oats—not a *backbone* in fact—they are just the long tip of the bract.

**Defective florets.**

Our barley is indeed curiously like and unlike the oats previously examined. What about the third undeveloped floret in each spikelet? Here we have the corresponding thing—a row of empty blossom, born only to die—between either row of the perfect florets.

Still the corn flowers all show a strong family likeness. They are covered up by chaffy bracts and these close over the florets instead of opening to insects all day long as sepals and petals do. Is the floret then content to fertilize itself?

**Wind instead of insects is the corn's messenger.**

Let us go to a cornfield very early on some bright sunny morning, and we may be able to answer the question. But we must look with all our eyes or the great wonder which gives us our daily bread may pass unheeded. All is very quiet and still, and we think of what Matthew Arnold said:

> "One lesson nature let me learn of thee,
> Of toil unsevered from tranquillity."

For all the time the little florets on every side are at work—swish! they open for a breathless fifteen minutes—those who remember the last lesson will know *how* they open—and the stalks of the stamens grow and grow, as if they could not grow quick enough; and behold! the loose pollen bags are thrust forward and hang out on each ear of corn between the bracts. Let any who doubt whether stamens can grow so fast put young ears up their coat sleeves—in a few minutes what do they find? Nay, the warmth of a school-room—let alone the warmth of a child's arm— is sufficient to stimulate this extraordinary growth. Leave a few florets lying about, and in less than no time each will be lying on a pile of its own pollen. But I hope we are in the fields, not the school-room, and that the children are shaking the standing corn and watching the pollen—lighter than dust—float out in clouds and fall. What quantities there are of it—wheat, it has been calculated produces 50 lbs. weight of pollen per acre. Think of the great heap a single pound of such light substance would make, weighed out on kitchen scales!

We have not answered our question yet—is the corn seeking to fertilize itself? Hardly so, for now the pollen bags sway far beyond the reach of the hairy pistil. Farmers always hope for fairly dry windy weather while "corn is on the bloom," and you know long ago we promised to reveal the great purposes served by elasticity. Now put two and two together. Not only the corn stem but every detail of the plant's structure down to the tremulous poise of the pollen bags, fits our plant to sway before a breath. The "little breeze so fresh and gay" which streaks the grass with ripples even on hottest summer mornings, is fanning us now, and gently wafting the clouds of pollen from ear to ear. Presently ruder winds may arise which would waste the previous store—but the blossoms are once again closed, their day's task is accomplished thanks to the hard-working stamens, and the corn is fertilized!

Now we know why the florets can afford to be so small and inconspicuous, why they grow so close to each other, and why they produce such a quantity of pollen. Even the most well-behaved little wind is a more shifty messenger than a bee, and some of the pollen is sure to go astray. They must grow close to each other, poor lean little plants, sharing all

things alike, and in their meek care for each other multiplying exceedingly and inheriting all the earth.

**Pussy willows and many other trees are wind fertilized.**

Can one of you remember a flower lately mentioned as having a woolly scale instead of petals and sepals? Many other trees besides the pussy willow are wind-fertilized. In consequence of their lack of colours we often do not notice them at all—even imagine, perhaps, that trees do not bear flowers at all. But nature leaves none of her children thus unprovided for.

**Summary.**—The various ears do not really vary much, and all contain a greater or lesser number of defective plants. They are either self-fertilized or wind-fertilized, but the florets only open for fifteen minutes. Wind-fertilized flowers are inconspicuous, have no smell, and produce vast quantities of pollen.

**Art.**—Design in brushwork to be based on above studies.

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## 21.—ASPARAGUS.

(*THIRD WEEK IN SEPTEMBER.*)

**The edible shoot.**

Which part of the asparagus plant do we eat? The fat spring shoots, you will say. (The earliest vegetables are those grown for the sake of young shoots, or, as in the case of rhubarb, for the young leaf stalks.) Let one of the class try to describe young asparagus—the closely-set leaves, and the fat terminal bud which they form; or, better still, let each child draw from memory on his slate. Let the beds next be visited in order that we may see what the uncut shoots have done during five months of summer. All we can recognize is the central stem, grown old and tall and thin!

**Scale-like leaves are short-lived.**

Whatever has become of the leaves? They seem all to have been executed and their corpses are hanging, shrivelled and yellow, at the base of branches large and small; they are even under each little green tip of the plant, though so small as to be hardly recognizable. Surely, they were only bud scales, such as we saw protecting young leaves and flowers from frost! But then there could have been no buds then nor branches now; we learnt long ago that a scale never cradles a bud. No, they were true leaves, but now there are no more like them, only needle-like points instead—they have been put to death and we want to know why. Well, you know, they lay so flat and snug against the sides of the young shoots that they could not possibly have done their duty of preparing food for the plant by means of sun heat (refer to Lesson 5). Our friend the asparagus probably found they were no good to him, and did away with his idle servants.


**The needle points are leaf-like branches.**

Well, but, you will object, — he is growing green and high—he should have died of starvation and withered away with the yellow scales. No, no! not so foolish—he got new servants, and perhaps owing to their likeness to fir needles, the children may suggest that the little points constitute a second growth of leaves. But who ever heard of a plant having two crops of the same organ, quite unlike each other—the second being unfolded buds produced in the

cradles of the first! Leaves grow on branches, not on the first leaves, even though they be similar to scales. So, since these little needles sprang from buds in the leaf cradles, what must they, contrary to all appearance, be? What but groups of branches which have given up all idea of living their own life their own way, just because they have stopped to do the work of the lazy withered leaves! All except a very few, who fortunately cannot be spared from their proper duty. Here and there one of a group of needles grows out as a proper branch, and here and there one has even borne flowers, as the berries show.

**Cultivated *versus* wild asparagus.**

Perhaps it will occur to some observing child to ask how the asparagus shoots managed to get so thick, while the leaves were so half-hearted. Luckily for the gardener, its roots were hard at work in the rich garden soil feeding the shoots very fast. The *wild* asparagus grows lean enough from first to last, preferring poor gravelly soil and putting all its strength into the production of plentiful berries. As we learnt last July, when we were studying the corn, a plant's chief concern is for its offspring.

**Is the asparagus an inside grower?**

It is a spreading plant, and yet some lilies mimic outside growers by producing branches. The scaly leaves may be straight veined, but this is difficult to ascertain in their withered state. If only we could find a flower that has not faded and count the number of its parts! But the berries are there, and if the flower was arranged in triplets, like the tulips and the corn florets, the fruit may perhaps be three-celled. And so it is! We may surmise then with probable accuracy that the asparagus is an inside grower. We know that five or four is the favourite number of the other class, and that their seed cases, if not single celled, are generally divided by 2, 4, or 5, or multiples of those numbers.

**Scattered fibre bundles.**

Now for a final proof. Let us cut the stem across at the thickest part, and we shall see dots, representing fibre bundles, scattered round irregularly. We know that if the

plant were an outside grower they would be formed in an even ring.

**Summary.**—The scaly leaves shirk duty and wither, leaving their work to needlelike points which grow in groups and which are here and there prolonged into proper branches. The plant is more nearly related to the lilies than to the grasses.

**Art.**—Studies of stems and berries to be made with the brush, and, afterwards, a simple diaper pattern. Haité's bold drawing of the asparagus may be studied with advantage, p. 38.

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## 22. BURDOCK.

(*FOURTH WEEK IN SEPTEMBER.*)

The children should be put through an unconscious recapitulation of the first lessons by a study of those trees which were observed in spring. Let them compare by measurements the length added to twigs of different kinds of trees, and also of old and young twigs on the same tree. They should be called upon to notice the difference between the north and south side of twigs, and not allow themselves to trust to single observations. Are twigs undergoing any change at this time? What visible preparation is there for the coming spring? Where does the tree hold its buds?

The class may then cut and fold a burdock leaf as directed by Ruskin on pages 146 and 147 of "Proserpina."

* (*a*) *The burdock leaf.* (*b*, *c*, *d*), *perspectives of the elementary form.* "Take a sheet of stout notepaper, Figure *A*, double it sharply down the centre, by the dotted line, then give it the two cuts at *a* and *b*, and double those pieces sharply back as at *B*; then, opening them again, cut the whole into the form *C*, and then, pulling up the corners *c d*, stitch them together with a loose thread so that the

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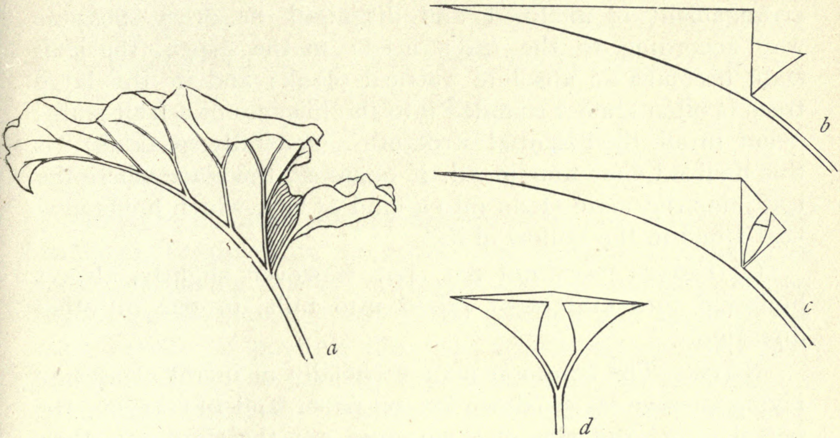
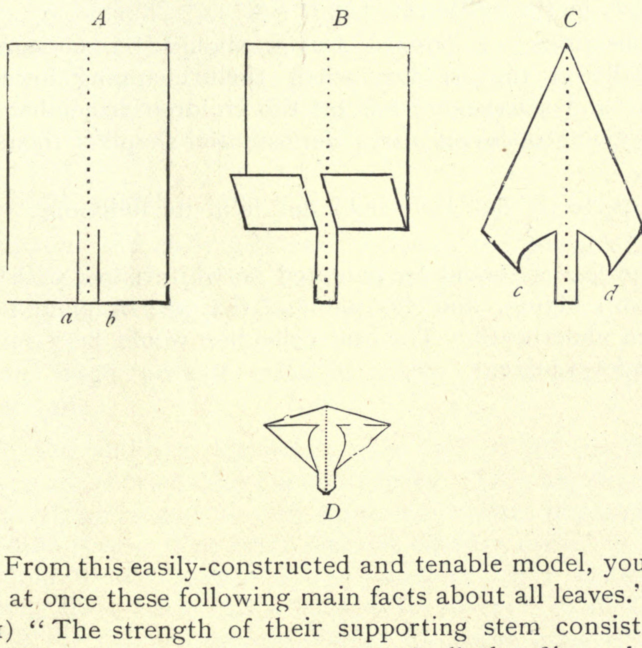
* Pages 146 and 147 of *Proserpina*, by John Ruskin.

points *c* and *d* shall be within half an inch of each other; and you will have a kind of triangular scoop or shovel, with a stem, by which you can sufficiently hold it, *D*."




"From this easily-constructed and tenable model, you may learn at once these following main facts about all leaves." . . .

(1) "The strength of their supporting stem consists not merely in the gathering together of all the fibres, but in gathering them essentially into the profile of the letter V, which you will observe your doubled paper stem has; and

of which you can feel the strength and use in your hand as you hold it. Gather a common plantain leaf and look at the way it puts its round ribs together at the base, and you will understand the matter at once. The arrangement is modified and disguised in every possible way according to the leaf's need: in the aspen, the leaf-stalk becomes an absolute vertical plank; and in the large trees is often almost rounded into the likeness of a fruit stalk; —but in all, the essential structure" (generally speaking) "is this doubled one; and in all, it opens at the place where the leaf joins the main stem, into a kind of cup, which holds next year's bud in the hollow of it."

(2) Leaves "are not flat, but, however slightly, always hollowed into craters or raised into hills, in one or other direction."

NOTE.—The common plan, especially in infant classes, of laying pressed leaves down flat on paper and of carrying the pencil round the edge of them, does not therefore give their real size, be the outline ever so correct.

Collections of pressed leaves should be encouraged, especially at this season, when their changing hues add variety and attraction; but let the children remember that this pressing of leaves alters the essential shape of them very much.

A perfectly flat leaf could not fulfil its functions. Why not?

The leaves should be mounted on white paper with slips of stamp edging, and the name of the tree or plant neatly written underneath. The best collection would be a suitable object for a prize.

# 23.—CABBAGE FLOWERS (1).

*(THESE MAY BE FOUND ON LATERAL SHOOTS QUITE AS LATE AS THE FIRST WEEK IN OCTOBER.)*

**The Cross-wort family.**

Let the children analyze flowers of the sea cabbage, field cabbage, turnip, rape, or any of the cultivated varieties of cabbage, paying special attention to the numbers of the sepals, petals, stamens, and to the position and shape of the seed vessel. If possible the class should satisfy itself that the flowers of the garden and of the wild sea cabbage are practically identical. Comparison should be provoked with the corresponding portions in flowers already examined, and it will be found that the flower to which these cabbage blossoms bear the greatest resemblance in chief particulars is the wallflower. In fact, it is a near relation, and belongs, along with cabbages, to the family of Crossworts, or "cross bearers." Why should the family be thus named ?

**Knobbed pistil.**

What is the chief difference between the cousins ? The wallflower pistil is forked, but in cabbage flowers we find the pistil surmounted by a knob.

**Pollen bags poised with a view to cross fertilization.**

Do the children remember why two of the wallflower stamens are shorter than the other four ? They are depressed by honey glands, and we now know why nature imposed this burden on them. The other stamens also are drilled to stand according to the wallflower's convenience ; but instead of humping their backs they have only to turn their heads. Now, if the pollen bags faced *away* from the honey-seeking insect, what would be the result ? No honey could fall on him—cross-fertilization would be defeated ! Examine long stamens in middle-aged or young cabbage flowers, and it will

be seen that the pollen bags are turned towards the short stamens, or altogether outwards. But the position of the bags on the short stamens themselves is even more important, because the insect touches them with one side of his head, while with the other side he knocks the pistil tips. It is precisely on these short stamens of the cabbage flower that the bags will be found turned inwards. When an insect visits several flowers in succession it is clear that cross-fertilization will most likely result. Thus is the tiniest detail of a flower's structure concentrated on purpose, and the very attitude of a tiny pollen bag has its meaning. The saying that the hairs of our head are all numbered is not more wonderful.

**Self-fertilization possible.**

In case no insect comes, do you suppose that such a minutely-contrived organism is at a loss? No, indeed. Perhaps some of you, by examining old flowers, may discover what a very curious thing happens. The long stamens turn backwards so that their pollen bags come against the tip of the seed vessel. Thus the cabbage has two strings to its bow, and does not run the risk of fruitless flowers.

Perhaps a late wallflower may serve for comparison. Does it behave as ingeniously as its cousins?

**Art.**—Diaper design of crossworts. The rosettes of leaves formed by seedling cresses and shepherd's purses will intermingle effectively with flowers drawn singly and full face forward. The heart-shaped outline of the fruit of Shepherd's Purse (meaning "Parson's Almsbag") contrast pleasantly with the linear cabbage seed vessels. Pods should be drawn in the act of splitting as well as in their entire form.

# 24.—DOMESTICATION OF CABBAGES (2).

(*SECOND WEEK IN OCTOBER.*)

**Causes of variation in plants.**

It is said that there are no two leaves in the world alike. Certainly there is sufficient variety on a single tree, as regards both shape and size, to fill the heart with awe and wonder. Let us imagine a few laurel leaves of the same age, and grown under similar conditions—how quickly our mind is exhausted! we find (before we have drawn a dozen perhaps) that we cannot invent further variation. A number of clever artists dress and drill the big trees, and even the little plants. Age, air, space, sunlight and food, all show their handiwork upon vegetation. Perhaps the difference has been noticed between dandelion plants of equal age and other circumstance, but one of which sprouts in the gravel of a garden walk, and the other in the rich soil of a flower bed. The leaves of the first are small and deeply cut; those of the richly-fed plant are broad, unbroken and spreading.

**Richness of soil an important factor.**

What is the difference between the soil of a ploughed field, and that of a waste place? The garden and the ploughed field are "cultivated," that is to say, they are broken up and manured; whereas the waste place is in a natural state—uninterfered with by man—the path being neither one nor the other, but purposely made hard, dry and, strong. If we were to compare the same kind of plant growing under all these different conditions, we should find the garden plant producing unnaturally large leaves, and the plant in the path unnaturally small ones—that is to say, smaller than those of the plant growing in natural (viz., probably medium) conditions.

**Nature's object is not always man's.**

We found that a plant's natural object in life is to produce seeds. Now we may be sure that man cannot improve on the

plant's way of gaining its own ends. If therefore he grows plants in the unnaturally rich soil of his garden, it is because his object is different. Do the children remember how they were told that the garden asparagus grows in poor sandy places, where it has found it can keep its tissue lean to the benefit of seeds? Why does man, on the contrary, place it under circumstances favourable to the production of strong fat shoots at the expense of seeds? It is because we want to eat the shoots, and we care nothing about the berries. All our garden plants must similarly once have been wild, and many, like the asparagus, have wild relations living still. Once under cultivation, their natural flowering habits are upset; in fact the plant and the gardener cannot each have his own way.

**Heredity in plants.**

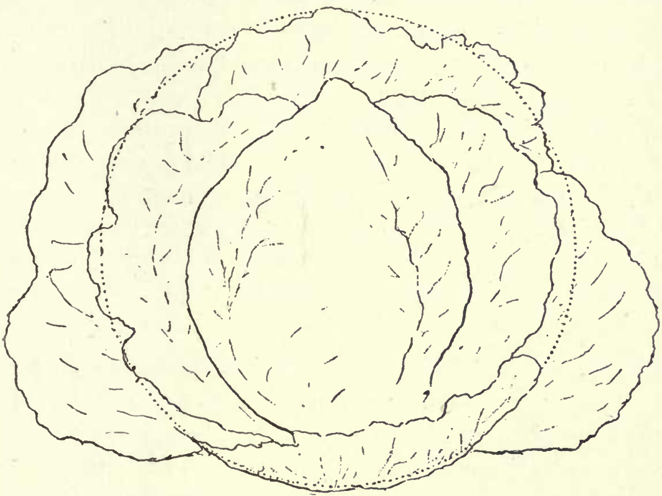
Which child has seen the red cabbage that grows by the sea? When gardeners, hundreds of years ago, wished to grow cabbages for the sake of their leaves, they took plants from their native gravel and put them into well-manured ground. Each time fresh plants were required, was the cultivator likely to fetch them from the sea shore and so begin all over again? No, he sowed the seed of those plants which had grown most to his purpose; for young plants, like young people, are wont to resemble their parents. Further, cross-fertilization doubtless played its part; we know that it results in stronger plants than does self-fertilization and it may play a great part in the skilful gardener's hands, for seedlings tend to resemble the plant by the pollen of which they were fertilized. Therefore in rearing cabbages, even now, plants are carefully selected for cross-fertilization; inferior specimens not being allowed a chance to increase themselves, for fear of a gradual return to the wild state. A good gardener will not allow cabbages to flower on his plot; he trusts to the nurseryman to supply him with carefully-reared seed.

**Variations are slowly established.**

It is only by sowing seed from chosen plants and giving each generation its chance to grow in the way we wish, that after a very long time any great change can be brought about.

Garden plants may look different enough to their wild relations but the changes have sometimes occupied hundreds of years.

**Summary.**—As a general rule, richness of soil encourages the growth of plants at the expense of their fertility. Those of our present kitchen-garden plants which have been grown for the sake of their leaves and stems have been produced through continual selection of rankly-grown specimens for propagation. Age, air, space, sunlight and food all produce variations in the form of vegetation.



**Art.**—Leaf of the sea cabbage, or of the wild field cabbage (or garden cabbage, if these are not to be had) to be outlined on a large scale in charcoal or in pencil. Guide to ultimate design. Notice particularly the decorative converging rib-lines, and mark in the principal ones.

# 25. SEAKALE, SAVOYS AND WINTER GREENS (3).

(*THIRD WEEK IN OCTOBER.*)

Let us examine seakale flowers, or, if they are over, then their seed vessels. We shall see whether they resemble the cabbage and belong to the Crossworts.

**Variations produced according to purpose.**

Do we eat the same part of seakale that we do of cabbage? The children will reflect that what we prefer in the one we care for least in the other. Of seakale we eat the young shoots and stalks of the young leaves. Sometimes the ribs or larger veins of the old leaves are pulled and eaten like asparagus. But, instead, we prefer in cabbage the soft green blade in between, the ribs themselves being very stringy to the taste; and consequently gardeners have sometimes caused this soft green part to increase in unnatural proportion to the sustaining rib work.

The starved dandelion of the gravel path shows hungry teeth all along its margin; but in between each tooth is stretched a soft green tissue which owes its juiciness to whatever nourishment the plant gets, and can therefore transmit to us. In the case of deciduous trees, this food travels into the stem towards winter and the leaf becomes dry and hard to the touch, the rib work or skeleton of the leaf being most of what is left. We can understand how a poorly-fed plant can produce but little of this green tissue, and being badly fed itself, gives little nourishment to man or beast. On the other hand the fatly fed cabbage is a capital instance of unnatural development brought about in a rich garden soil.

**Varieties of Cabbage.**

The different kinds of cabbage which we enjoy nowadays are probably all descended from one and the same wild cabbage; but gardeners encouraged different kinds of variation and established each through heredity in the seedlings. Which child can make out the longest list of cabbages that

are grown for the sake of their leaves (*e.g.* white, red, blistered or savoy, and the borecoles or open-leaved cabbages, which instead of being crowded into a tight head like the preceding, grow in a more natural way with long stems) ?

In 1806 there were fourteen different kinds of cabbage, now there are over one hundred.

**Summary.**—Seakale is eaten for the sake of its ribs ; leafy cabbages, such as savoys and winter greens, for the sake of their blade. They are grown in rich soil, and, as a result of fat feeding, are nourishing to man and beast.

**Art.**—Outline a purple cabbage leaf life-size in pencil or charcoal, marking the principal ribs only. Then wash in the glorious colour with paint. Compare the colours of amethysts in a jeweller's window.

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## 26. CAULIFLOWER AND RAPE (4).

(*FOURTH WEEK IN OCTOBER.*)

### Cabbages grown for blossom.

Do we grow cabbages for the sake of their leaves only ? What about cauliflower and broccoli, of which we eat the flower shoots ? Some may question—why not eat the shoot of the wild flower ? But any children who have seen it know that it is too thin and poor and stringy to the taste ; whereas the pampered cauliflower does not trouble to grow half so tall, but is all thickened out, fat and fleshy instead. The flower-stalks all grow close together just as we saw the leaves do in headed cabbages. Let the children themselves explain how these fat flower heads were probably brought about (through soil, perpetual selection of the fullest fattest heads for propagation, etc.).

**Cauliflower *versus* broccoli.**

How would this class distinguish a broccoli from a cauliflower? By its purple or white hue. It is better able to stand the winter than the cauliflower, probably because bright green tissue requires most warmth and sunlight. The young leaves of many plants are tinged with purple.

**Rape or colza grown for seed.**

The production of seed is exhausting to the plant, so much nourishment is required to ripen it. Here is another reason why gardeners do not allow their plants to run to seed if the leaves are required for edible purposes. Can one of you, however, mention a kind of cabbage which is grown, not for the sake of its flower, nor yet of its leaf, but for the sake of its seed? Let us try to answer one question by means of another. Which of us knows the genesis of colza oil? It is pressed from the seeds of rape or colza; in Normandy broad acres of yellow blossom may be seen blowing for this purpose. The dry part of the seed which is left is called rape-cake. It makes an excellent food for cattle.

The wild rape grows about the corners of our fields, so that we may examine the wild flower if there are no rape crops at hand.

**Rape blossom.**

We shall find it almost exactly like the cabbage flower; and, indeed, the wild rape is supposed to be just a variety of the wild field cabbage, which is, perhaps, an ancestress of the turnip. But we shall go into this matter another time, and realize, perhaps, what queer relationships there may be amongst plants.

**Annual *versus* biennial wild cabbage.**

If the thick root-like underground portions of the wild field cabbage and of the sea cabbage are compared, those of the latter are seen to be larger and thicker. It has something to say to the length of the plant's life—how and why we may learn later on. Meanwhile, which of us can tell how long the field cabbage lives? Alas! it only survives a single summer, poor thing; but the sea cabbage is a biennial, it lives through the winter and grows for two successive summers.

**Summary.**—Cauliflower and broccoli are cabbages grown for the sake of their blossoms and of their thick fleshy stalks, whereas rape is grown for the seed from which colza oil is obtained. It is supposed to be a variety of the wild field cabbage. One of many differences between the latter and wild sea cabbage lies in the size of the rootstock and consequent term of life.

**Art.**—Place a cauliflower before the class, face tilted slightly forwards. Let it be at such a distance as to appear on a reduced scale. It may then be attempted within the limit of slates. At the same time it should not be so far away as to confuse the main facts. These should be noted very simply. See "Nature's Alphabet" or "Sand Lessons for Little Ones," by Miss Mumbray.* At the end of the book are simple drawings, based on circles, of cabbage, cauliflower, and brussel sprouts. (They are intended to be drawn on sand by very young children, and demonstrate how an apparently confusing and difficult subject may be mastered.)

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## 27. THE TURNIPS.

(*FIRST WEEK IN NOVEMBER.*)

**Turnips = Cabbage grown for root's sake.**

We have learnt about cabbages grown for the sake of leaf, stem, blossom, and seed respectively. The turnip is yet another kind of cabbage which is grown for yet another purpose. Now, which child can tell what it is we grow turnips for? What but the fleshy root, of course! Turnip seed is not abundant nor worth the trouble of extracting oil from it.

**Turnips proper *versus* turnip cabbage.**

The turnip is to be distinguished from the turnip cabbage by its dull leaves, and is a descendant of the wild field cabbage. The other springs from the sea cabbage, being a variety of borecole or winter green.

**Swedish turnip.**

Another rooty cabbage is the Swedish turnip. It is considered to be a variety of the English turnip. Let as

* Published by O. Newmann & Co., 4s.

many of these turnips as possible be examined and compared. What method is adopted in crossing two varieties such as the Swedish and English turnips? And what, besides a great variety of appearances, are the effects produced? (Improvement of quality and hardiness.)

**The wild turnip—ancestor or descendant?**

There is a wild as well as a cultivated turnip. Some people think it has degenerated from a cultivated specimen, being an escape from gardens. Others say that it is the ancestor of the cultivated turnip, and that the wild field cabbage is an escape. To settle this point one might as well try to decide whether the egg came first or the hen. Still there is a way in which we may set to work some day and perhaps answer the question.

**Degeneration.**

How wild plants may eventually become garden plants, suitable for food, we have already discussed. But even the artificial conditions that pertain to a garden could not turn a wild plant into a cultivated plant all at once. *Vice-versâ*—supposing a plant has after long cultivation outgrown natural conditions, and become what is called a cultivated plant, do the children think it would preserve that state if allowed to return to natural conditions? No, it would run wild again, losing all so-called "improvements" much more quickly then they were acquired. If then, we were to let turnips grow in poor uncultivated soil, they would soon dwindle, and we should observe whether in that state they more resembled the present wild turnip or the wild field cabbage. Or we could proceed on opposite lines and see what wild plants become in the course of generations under cultivation.

So long ago as the reign of Queen Elizabeth, Bacon recommended experiments of this kind—to overrule the seed by nourishment, placing marsh herbs on hill tops, mountain plants in valleys, and so on. "The rule is certain," he said, "that plants from want of culture degenerate to be baser in the same kind, and sometimes so far as to degenerate into another kind."

I. "The standing long, and being removed, maketh them degenerate."

II. "Drought, unless the earth of itself be moist, doth the like."

III. "So does removing into worse earth or forbearing to compost the earth (as we see that water mint turneth into field mint and the colewort into rape by neglect, etc.)"

**Natural and unnatural conditions.**

The children should be encouraged to form an accurate estimate for themselves of the difference between natural and cultivated conditions. Under the latter, soil is enriched; moisture supplied; space for each plant is provided—each having sufficient air and sunlight in consequence; and finally the soil is broken up.

**Effect of stiff soil on roots.**

Roots can penetrate light soil more readily than a stiff and heavy soil. For instance, there are two kinds of garden radish—one has a long, the other a stumpy, turnip-like root. A good gardener can produce either of these kinds from the wild radish, according as he grows the plants in light or stiff soil.

In the same way short rooted carrots have been known to yield long rooted plants in the first generation.

**The great possibilities of variation.**

Gardeners' methods can cause a vast extent of variation; *e.g.*, in little less than 100 years, the number of cabbage varieties has increased from fourteen to 100.

**Similar possibilities in the animal kingdom.**

The children may enumerate all the different kinds of pigeon, dog, or cow they know; any domestic breed being an instance of the variations caused by men with the limits of a single species.

**Summary.**—Plants rapidly degenerate on their return to natural conditions. The wild ancestors of our present garden varieties may thus be determined. Turnips are perhaps descended from the field cabbage, and the turnip cabbage from the sea cabbage—or else the present wild turnip is the ancestor

of both turnip and field cabbage. Both carrots and radishes have their wild representatives; and differently shaped roots can be produced from them according to the light or unyielding nature of the soils.

**Drawing.**—Outline a turnip plant, root and all—either a charcoal study or a chalk outline to be filled in.

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## 28.—BRUSSEL SPROUTS.

(*SECOND WEEK IN NOVEMBER.*)

**Cabbage bud cradles.**

We have already learnt that leaf stalks are often hollowed and consequently strengthened. But a second purpose is thereby secured as well. Note the position of tree buds at present forming, and you will remember what we have already learnt in previous lessons that the joints of branch and main stem furnish snug cradles for the buds. Some leaf stalks are more hollowed than others and thus shield buds the better. But now let us look at the stalks of cabbage leaves (in the stalked varieties). They are so thick, their overgrown tissue seems to swamp the whole space, so that the stalks look flat. Only in Brussel sprouts do we see a shallow narrow groove. Where, oh where, is there room to tuck a bud, and how small a baby it must be if cradled there at all! Let us pull the leaf stalk right away from the main stem sharply; and sure enough, the tiny thing will be found.

**Short stemmed buds of Brussel sprouts.**

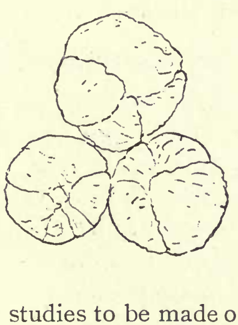
But if we examine Brussel sprouts, behold! no buds, but little cabbages! so will all the children say. They have usurped, then, the proper niches for buds; let us make sure that they are not buds in disguise. In another plant, the leaves composing them would have been separated by intermediate growth of stem, and we should see branches instead

of sprouts ; but culture has encouraged the leaves at the expense of the stem; so you see these little cabbages have really been proper buds and would now be branches but for Mr. Gardener. *Cf.* the scale leaves of bulbs—how closely they are set owing to the suppression of the central stem! And we have seen in many trees and plants how two leaves are often left close together, or even more—so many, indeed, in the case of the woodruff, that they form an Elizabethan collar round the plant's stem. If we pull a sprout to pieces we shall discover the dwarf stem tucked away out of sight between the leaves.

**Sprout buds have small cradles.**

Again: let us find the cradle from which the sprout-bud springs by breaking a leaf stalk gently and firmly away from its very base. It is a tiny cradle compared to the great width of the leaf stalk and the great size of the sprout. "You will be so big afterwards, you shall be cramped now"—so the grudging plant seems to say.

**Summary.**—Buds are cradled in the hollow of the leaf stalks at the base of them. Sometimes the space is niggardly, as in the cabbage tribe. In Brussel sprouts, the bud leaves have been encouraged by culture to develop without proportionate elongation of the stem.



**Drawing.**—Large studies to be made on the slates of sprouts.* Outline attachment of a stalk to the main stem in some instance where the bud has hardly sprouted.

*See simple outline in Mumbray's "Nature Alphabet," or Sand Lessons for the Little Ones, at 4s. (Newmann & Co.).

## 29. WATER-RUNS ON CABBAGES.

(*THIRD WEEK IN NOVEMBER.*)

**Different position of old and young leaves.**

Which child can say whether all the leaves on a cabbage plant slope the same way? Some are surely far more upright than others—namely the vigorous young ones; those next in age flatten out horizontally; and the lowest, the oldest of all, hang their disconsolate heads downwards. None of the leaves, however, are truly flat in themselves, for not only may they be all over bumps and hollows, but the frayed parts at the base of the blade bend steeply downwards, away from the mid rib and the rest of the leaf.

What trifles! you will all exclaim. But Nature does not trifle with any of her children. Suppose you think *why* the leaves are thus variously placed.

**Struggle for light.**

Why should they not all grow upright together instead of nodding and bowing as they get older? Poor things! even supposing they did not get flabby with age, bending weakly, how they would all cramp and keep the light from each other! They politely get out of each other's way so that there may be light and space for all.

**Conduct of water by leafstalks.**

But there is yet another reason, and a very important one, for this varied position of the leaves. It may be remembered that the hollowed leafstalks of the burdock framed deep gutters leading to the tapering root, whereas the cabbage leaf stalks were hardly grooved at all. Now let us see how our cabbages gain water supply in spite of an apparent difficulty, and at the same time perhaps we shall learn why the leaves are so poised.

**Upright leaves are accompanied by a spindle root.**

First, let a young plant be watered. The water runs down the upright blades, and then dribbles from each to

each, till it reaches the ground close to the base of the stem. Now what shape is a cabbage root? You will remember that in the young plant it is straight growing and little branched—so the water runs to exactly the right place.

**Spreading leaves are accompanied by a spreading root.**

Next, water an old plant. The water runs down the central, upright leaves as before. Thence it drips on to the hanging basal parts of the middle leaves. Lastly, it runs on to the lowest leaves of all, whence some of it finds the same direction as before. But most of the supply runs down to the tips of these lower leaves, hanging outwards as they do; and thus the water reaches the ground at a distance from the roots, you will say! Poor thirsty old cabbage! But do not pity it too soon. It does not look as if it suffered from drought; and indeed, if you pull old stumps up you will find that, tugging with might and main, you bring away long spreading root branches which have grown out towards the circle of moisture. They have not necessarily been attracted by it—perhaps they have grown out because the best soil is near the surface, and the central tap root could not keep pace with the growth of the leaves without boring into very poor regions where it might not have found food enough, and where it might only have become but a rotten sort of anchor for the great top-heavy plant. In any case you see a perfect harmony prevails between root and leaf—each seems to conspire for the other's good.

Sometimes the leaves are very cup-shaped—presently the curious may learn why, though perhaps the sharp-witted know already without being told. But meanwhile only notice that the cups are not allowed to steal water from the roots—the edges hang over to conduct the overflow; and sometimes the leaf, after storing the water (so it would seem) against dry weather, gets tired of its burden and tips it all over.

**Rainfall on trees.**

Now let the children explain why there is a charmed circle of dry ground round the trunks of those trees which give shelter in very heavy rain; bearing in mind how the water would follow the slope of the leaves and so cause extra

moisture all around outside. Also why gardeners sometimes dig a trench round trees at a certain distance—what distance?

**Summary.**—The position of leaves above and of roots below is so related that the water supply is carried to where it is most needed—the position of the leaves being in the first place determined by the struggle for light. The growth of the lateral branches of the cabbage root is accompanied by a growing tendency on the part of the old leaves to bend outwards.

**Art.**—The children may outline on their slates a skeleton tree trunk with branches (say a larch) from memory. If they have studied a cabbage in the class-room (instead of watering plants in pots or garden, which would of course be best), they may draw it as large as the paper or slate admits in most simple outline; water runs to be shown by dotted lines.

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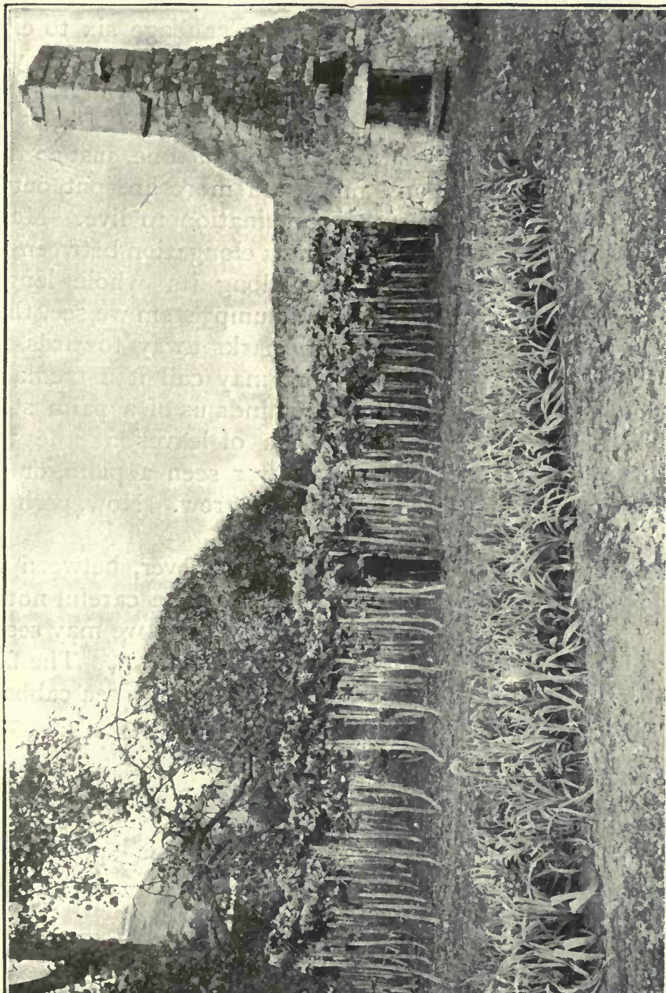
## 30.—THE TREE CABBAGE.

(*FOURTH WEEK IN NOVEMBER.*)

**Recapitulation of former lessons.**

Let the children explain how a wild cabbage plant takes care of itself. Each part fits in with all the rest, helping the plant as a whole to get on in the world, to be fruitful and to cover its allotted spot. The roots in their underground quest for food, and the leaves in their endeavour to secure light and space, are at the same time working for each other: the anchoring roots below are watered by the leaves above. These again are poised to best advantage by their stalks; which latter, in the same act, cradle and nurse the little buds. The older parts of the plant shelter the young leaves and the young blossom. Each flower in its turn guards the seed and provides for its fertilization and dispersion.

Man, by artificial conditions, tries to develop one part at the expense of the rest; he creates a greedy growth to flatter



Tree Cabbages (Jersey).

his greedy palate. We have seen curious roots, leaves, buds and blossoms. Now we have only one more funny thing to study, and that is a gigantic stem.

**Tree Cabbage.** (Recapitulation Concerning Stems.)

Which of you has ever stood under a cabbage six to eight feet high—as tall as, therefore, and perhaps taller than your father? They are seen across the channel in Normandy very often, being grown there for the sake of the peasants' live stock; the leaves are stripped off, a few at a time, just as they are wanted, for fodder; and more and more are put out by the persevering cabbage in its determination to live. Meanwhile the stem gets taller and taller by elongation between the leaves. You remember, it grows along its whole length. Otherwise, instead of the scarred and lumpy stem we see, there would only be a tight patch of leaf-marks away towards the base of the trunk. Yes, indeed, we may call it a trunk, so stout as well as high it is; and it reminds us of a palm stem, scarred all the way up with a bunch of leaves at the top. Perhaps if one of the children has ever seen a palm, or the picture of one, he wondered how it ever grew. Now, perhaps, he can explain the mystery.

There is an important distinction, however, between the palm and the tree cabbage, which he must be careful not to forget. The cabbage is an outside grower, as we may see by the sections of any small stumps in our gardens. The fibre and pith are regularly arranged in a ring; and the sea cabbage, because it lives two years, or even more, shows a second (sometimes a third) circle of fibre bundles outside the first.

How long does our tree cabbage live? *Cf.* with it the previously studied headed cabbages which seem to sit close to the ground, and the long stemmed Brussels sprouts and broccolis with dispersed leaf scars.

**Pot culture of variations.**

Doubtless by this time the class is eager to alter the growth of some familiar plant. Supposing there is a pot of seedling mignonette in the schoolroom window. Select a strong upright plant and strip off its lower leaves. Take great care of it, water and sun it well, but never leave any more leaves on it than a few at the tip. When the flower

bud appears, nip it off. By this time the stem will have begun to grow very stiff; buds will appear in the cradles of the remaining leaves; branches will put out; bark will form. Behold, a minature tree instead of a weak-stemmed sprawling annual!

Heliotrope and geraniums may also be treated in this way.

But whatever you plant, you must be patient and take time.

**Art.**—Outline a young borecole in the same manner as the headed cabbage of the last lesson.

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## 31.—CABBAGE RIBS.

(*FIRST WEEK IN DECEMBER.*)

**Ribwork constitutes an armour.**

Which does Jack Frost most cruelly nip—young growth or old? How do the buds and soft, juicy young leaves gain extra protection? By scales and sheathes and hairy coats, you will say, and by the way they are folded. How does the melon flower protect its large petals in their infancy? Do the children remember their strong veins between which the tender blade lay creased? Similarly it will be found in a very young cabbage leaf that the veins and ribs are the exposed part, and the soft green tissue is folded snugly away in between. It takes more time to grow than the ribwork, and there is less of it in proportion as yet.

**Old leaves take care of young.**

Is there any other way in which the young leaves are shielded from harm? They are right in the very heart of the plant—all the outer leaves spread shield-wise over each other, and, above all, over the babies within—the oldest and most tough being the most exposed. They have thrown their

arms round the babies, and will not suffer them to be hurt. Compare the scales of tree buds which have to weather long months of winter. Also the work of sepals.

**Cause of cup-shaped leaves.**

Now can one of you guess what causes the cup-shape of many of the old leaves?

After hooding over the young leaves so long, they did not all succeed in straightening themselves out again, when no longer needed. Leaves are like children. Once they get into the way of hunching their backs they do not find it easy to alter their habit—and so we see among the old leaves a number of Humpty Dumpties.

**Strength of ribs.**

We noticed in a previous lesson how these cups filled up with water when it rained. How is it they can support the weight? It is all thanks to those same useful ribs which protected the rest of the leaf in babyhood. Let the children break off a cabbage leaf roughly, so as to expose some of the great strands which contribute towards the main rib. They are slightly elastic and will bear pulling out a little way (*cf.* the strands in elder twigs, plantain leaves, etc.). These strands leave dots, such as we saw on the horse-chestnut leaf scars, wherever we break them off. The cup-shape of the leaves is of course only an accident; the leaf in any case requires strong ribwork owing to the great breadth of the leaf blade. *Cf.* a plantain leaf which has great length to support instead of breadth. (*Plantago lanceolata* is known by the appropriate name of "Ribwort Plantain.")

**Relation of shape, position and weight.**

Which is easiest—to carry a load at the end of a long stick or a short one?

Is it easiest to carry such a load above one's head or sideways?

Now look at the leaves: the narrowest are those which stand upright—edge sunwards. If these leaves when they take up a horizontal position continued to be so long in proportion to their breadth, there would be a great strain

on the leaf-stalk. But along with change of position they become broader. That is to say, the green tissue between the ribwork enlarges very much. Thus the weight is adjusted to the stalk, which is long or short according to what it has to carry. And right powerfully it performs its task—the great heavy leaf joining it at just the right place.

*Cf.* how the stalk of the water lily gets as nearly as possible under the very centre of the round leaf and its radiating ribs. Which of you, in some great garden, has ever seen the giant of the family, "Victoria Regia," imported from African lakes? It caused a duke's gardener to conceive the plan of the Crystal Palace which—do you know?—is built of iron ribs with glass between. He was knighted for having devised such a wonderful structure—so light and yet so strong in spite of its brittle walls! It was a great invention; yet water lilies floated before historic times.

**Summary.**—Young leaves are protected by a roof of older leaves, and also by their ribwork, between which the soft green tissue lies folded. This connecting tissue grows later on faster than the framework, so that the latter has to be very strong in order to support the great expanse of full blown leaf. The whole leaf is shaped and balanced so that the weight may be thrown as evenly as possible on the supporting stalk.

**Art.**—Design based on cabbage leaves. To be composed of charcoal lines, instead of blocks of colour as in a brushwork design.

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## 32.—NATURAL *VERSUS* HUMAN SELECTION.

(*SECOND WEEK IN DECEMBER.*)

**Causes of variation.**

Let the children recapitulate the means at man's disposal for producing variety. Bailey, in his "Lessons on Plants," states the case thus: "More heat, less heat, more food, less food, more water—training, growing under glass or in the shade, or in the sun—these and other factors which the

horticulturist has at his control cause, or at least bring out, the differences in plants, or he can produce differences by crossing. The variation is the start; selection does the rest . . . the kind of lettuce plants which are left is determined by the man who thins the row." By "selection," of course, is meant the choice of the plants which are to be allowed to propagate themselves.

**Natural selection.**

We may easily see that some of these causes might accidentally work on plants in a state of nature, apart from any human interference. For instance, seeds may drop into unusually wet kind of soil, and the descendants of the seedlings might ultimately acquire some characteristic of bog plants. By and by a new variety of the species might thus be established. The question arises—How long would this new variety last? That all depends—perhaps you will say—on how well it may be able to fulfil its natural object of producing seeds. Well, it is only those plants which ripen the best seed that continue to exist—there is only room in the world for a few to come up, and weaklings are pretty sure to get choked.

**Man's selection as causing length of days.**

The gardener, on the other hand, gives each plant plenty of room, so it need not only be those plants which increase the fastest that prosper. Now we have already seen that seeds are only perfected at heavy expense to the plant; it has to bestow all the food it can prepare on its family. Hence many of the ancestors of our garden plants are annuals; the field cabbage is an annual, and so is the carrot. These plants run to seed at the end of their first year; and having done their work, they die. But man, by inducing the plants to put off flowering and to grow fleshy roots instead, obtains biennials or plants which last two years. At the beginning of the second year the plant is able to renew existence by means of the root food stores, just as you remember bulbous plants start life with the help of food laid up in the fat underground scales of the bulb. A French gardener once raised garden carrots from the wild kind in four generations of plants. How do you suppose he did it? Simply by always selecting the seedlings which came up latest, and had therefore no time to

flower before winter set in. They had to make up their minds to spending all the winter in the beds, and could not flower till the following summer. Sometimes carrots and radishes "run wild." What happens then? They produce no crown tubers; that is to say, they store up no food in their roots, and die in their first year.

Now let the class explain how well-behaved parsnips and turnips and carrots live in the garden if left to themselves. They remain in the ground all the winter and do not flower till their second season. Then at last they die.

**Man's selection as shortening life.**

Here is one more curious fact before we leave the subject of roots. It is a reverse case to those which we have just considered, being that of a plant of shortened career.

The common beet is a perennial in its wild state; that is to say, it persists for an indefinite term of years. It is cultivated for the sake of its root; and when this is enormously developed it is called a mangold-wurtzel. Unlike the wild plant, it only lasts two years; it seems tired out by the strain which our farming has put upon it; and the very result which should have helped the plant to persist—viz. a great root store—causes it to perish prematurely.

At present there are forty-two varieties of beet in cultivation, and at the beginning of the century there were only six. How many kinds can the class enumerate?

**Summary.**—Variation caused by altering conditions of food, climate, space. It is established and propagated by natural selection if helpful to the plant in the struggle for existence. It is established by the artificial selection of man, if it is of advantage to the latter.

**Art.**—Varieties of root belonging to a single kind of plant—say, long and short carrots—to be drawn very large, with both hands, in coloured chalk. (See p. 215).

*33rd LESSON FOR THIRD WEEK IN DECEMBER.*

Let the class first compute the ages and tell the histories of a variety of fruit twigs.

Then let each child select a twig and write out its history, making illustrations in pencil or pen.

This ought to be a prize competition with which to wind up the year.

# SECOND YEAR'S COURSE OF STUDY.

## 34.—RHUBARB.

(*FIRST WEEK IN JANUARY.*)

[If possible the children should inspect young rhubarb that is actually under the forcing pots. A greater number of illustrations to this lesson will then present themselves than if the class merely sees a bud or two in the schoolroom.]

**Protective bud sheath.**

What a warm waterproof overall wraps up the young rhubarb! It is a homely brown sheath when the bud grows in the open air, but it becomes a gorgeous crimson robe beneath the forcing pots. It is rent apart when the leaf inside has grown old enough to take care of itself.

**Ribs folded away and covered by the blade.**

You will see that the leaves of young cabbage and of young rhubarb adopt opposite tactics. The cabbage leaf, like many another, says to itself: "My tender baby blade shall be folded so tightly between my ribs that neither frost nor wet shall reach it. My hard ribs shall be exposed to every danger." But the rhubarb leaf says quite an exceptional thing: "My big crumpled blade is much tougher than my poor little baby ribs. It shall be exposed, and the ribs shall be hidden away safely." Accordingly, when we tear the sheath off the bud, only the tightly packed crests of the blade are visible, making a furrowed, lumpy surface.

**Exposed blade crests are hard, shiny and coloured.**

Perhaps the class will remember that when we were talking about purple cabbage, we said that young vegetable tissue was often tinged with red, which colour is less

dependent on sunlight than green, and denotes the presence of something in the tissue which helps to keep it warm. Accordingly, the crests of our rhubarb are often pink or brown, brown being a colour which you probably know how to obtain by mixing red and green. These parts are also more shiny and hard than the portion of the blade which is crumpled out of sight. All this may be best noticed on exposed plants in wet weather, when the rain may be seen running off the hard smooth surface. A veneer of gum seems to turn the wet. *Cf.* the sticky varnished scales of chestnut buds and other trees and plants.

**The fabric of the sheath.**

Carefully examine a rent rhubarb sheath. It plainly shows along its torn edges the inner and outer skin, also the intermediate stringy matter (cellular tissue) of which all vegetable organs are composed. Leaves, however thin, all possess this inner and outer skin, and it is in the tiny space between that the plant's food is busily prepared. If you hold up a thin slice of orange fruit to the light you will see that the juice is contained in innumerable tiny bags or "cells." The kitchens of the leaves are all composed of similar cells, packed away between the inner and outer skins—so wee you cannot even see them. A protective kind of leaf like the rhubarb sheath does not contain much soft tissue, and the skins are extra thick and hard to resist the weather.

What do we call the skin of a tree trunk or of a branch?

The careful observation of leaves in respect to their treble nature will greatly help the children to understand fruit structure later on.

**The framework of vegetation.**

The ribs are composed of very much elongated cells, with often woody walls. They form cords or strands which are more or less elastic according to the kind of plant and according to the age of the leaf. The children should experiment how far these cords admit of being pulled without breaking. Tear off a cabbage or plantain stalk roughly, and the cords will hang out. Then, gently pull—pull.

The muscles of animals are wrapped in a stringy tissue which must have been noticed by the children whenever they have watched the preparation of meat for cooking. The

same term is applied to the cords of the leaf and to the membrane of muscle—namely, fibre.

Plants and animals are not so very differently constituted then, after all! Here is a great fact in common! Nature has a few ideas and applies them in hundreds and thousands of ways according to her purpose.

**Forcing.**

Which child can explain the advantage of growing rhubarb under covered pots? Do we not thus create a mock spring climate and "force" the rhubarb to put out early shoots?

**Summary.**—The rhubarb bud is protected by a strong sheath. When it is rent apart, the hard, shiny crests of the leaf blade seem to mimic the aspect and function of a sheath. Leaves are composed of inner and outer skin between which lie the "cells" in which food is prepared for the plant.

**Art.**—The children may make an outline and fill it in of leaf, stem, and bud, in coloured chalk. Or a pencil or charcoal outline may be washed in with colour.

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## 35.—SEEDLINGS (1).

(*SECOND WEEK IN JANUARY.*)

[The teacher must have a supply of scarlet runner beans, cucumber, and radish seed for each child to grow in a little box or saucer to be kept if possible on its own desk. We should be encouraged in an apparently difficult task by the example of an American school mentioned by Bailey ("Lessons on Plants," p. 449), where fifty-five boys of a class grew seeds in the cigar boxes which they had whittled to fit their desks. Even egg shells were used for the same purpose!

Radishes may be sown in a dark place; and various seeds should be placed in sawdust, or cotton wool and in the folds of heavy cloth; all of which must of course be kept damp. They are interesting experimental substitutes for soil. Each child should keep a log book and enter the first appearance of seedlings, whether these begin to sprout on the day for the botany lesson or not.

In addition to above-mentioned seeds, the children may look for chestnuts, sycamore "keys," etc., to plant.]

**Warmth and moisture requisite for germination.**

The necessity of keeping in warmth and moisture may be impressed on a child's mind by pointing out how tough nature has made the seed shell. What a task for the baby plant inside to force its way through! It has no beak like the young bird, wherewith to break the home which has sheltered it for so long. Perhaps a little thought may enable us to guess how the poor wee thing manages.

We know that the sycamore keys we love to collect lie about on the ground all winter. They wait for the spring, and perhaps some of us remember that then they become soft and swollen like beans and peas which have been in a cooking pot; and the skin comes off with a touch. Is it heat alone which bursts away the prison walls? No, for we know that if we put seeds into an oven they only shrivel up harder than ever. But heat combined with moisture swells the rice for our puddings (ask the girls how long they would soak a cereal to make a pudding), and out of doors it coaxes the baby plant into growth. While this swells the shell of the seed has to stretch, and at last bursts to let the prisoner through. Now, in January, the seeds are still sleeping; it may be wet but there is no hot sunshine. The class must try to produce an artificial spring in the schoolroom. Pieces of cardboard—or, better, of glass,—put over the boxes will help to preserve warmth and moisture in the soil.

Do not bury the seeds too deep (some may be left quite on the surface by way of experiment), and break up the soil before sowing;—remember that difficulties for the poor little plant are not over when it leaves the shell—soil is often hard and heavy for such a weak young thing to struggle through.

**Size of seeds.**

Are big seeds always found on large trees and tiny seeds on small plants? No, we shall know that such a rule won't do if we compare sycamore seeds with beans, or with cucumber seed which have undergone fewer alterations by cultivation. The greatest things are sometimes the offspring of the least—remember the Bible verse. Let us take the measurement (length and breadth) of one or two beans and mark carefully the spot of soil they occupy. In a week's time we shall see to what extent they have swelled.

**Shape of seeds.**

We expect to find the shape of the baby plants varying with the shape of the seeds we sow. This will give us further material for observation. It may be as well to notice at this stage that every seed has a little bump somewhere on its surface, and also a minute hole which is the seed's mouth, and through which the pollen passes. The observation may be made on big beans; on small seeds, it is difficult without a strong magnifying glass. We may learn the meaning of the bump later on.

**The scar of the seed stalk.**

Who can tell what has caused the big scar on the side of the beans? It reminds us of the scars left by leaf stalks, and whoever has shelled peas or beans must have noticed that they are not loose in the pods. How are they attached? Each by a stalk; the scar then is made by breaking this stalk off. Through the tissue of that stalk the pollen travels in order to reach the seed's mouth, which is always found close to the scar.

**Summary.**—Seeds vary enormously in shape and size; bulk not being necessarily the result of a large plant. The orifice through which the pollen reaches the germ may be detected in large seeds, such as the bean. The seed stalk leaves a scar where it is broken off. Warmth and moisture are necessary to germination.

**Art.**—After each lesson on seedlings the children should illustrate the log-book entries with pen or pencil,—always drawing much larger than life-size. A great part of the time allotted to this lesson will have been spent in sowing the seeds, so it will suffice if an outline of each seed be made; the position of stalk scar, lump, and mouth (if visible) to be marked on each. Notice subtle differences; for instance, the shape of cucumber seed vessels necessitates attachment of the seeds by their end instead of by their side.

# 36.—SEEDLINGS (2).

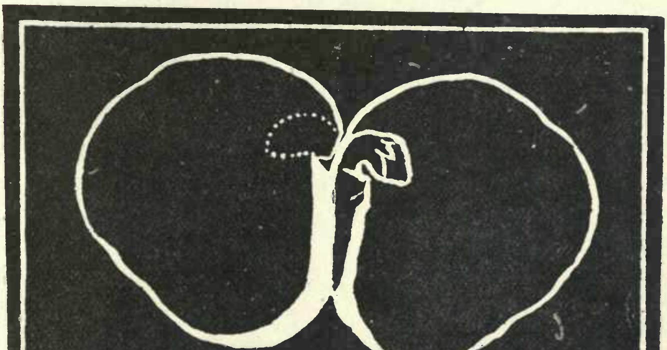
(*THIRD WEEK IN JANUARY.*)

**Swelling and softening of seed before sprouting.**

Let us unearth the measured beans and ascertain the bulk of seven days' swelling. The little plant has certainly begun to wake up, and the shell of the seed is softer. It is called the "seed coat," and commonly splits in two.

**The primary bud.**

Meanwhile peel it off, just as you might raise the blankets of a cot in order to have a good look at the baby. Is it not a strange-looking object which promises one day to be a green plant? Notice the two fleshy cakes of substance pressed closely together, and jointed on to one another towards their



The young pea and its root with a seed-leaf on each side (the blankets). Dots mark hollow left by plantlet (Le Maout)

extremities like an oyster or mussel shell, and perhaps, similarly, with something yet unseen, hiding between the valves. Sure enough, what is this little spike tucked away in a groove? Perhaps, while all are wondering, the resemblance to a bud may strike one of the children. This is just what it is—a baby stem with tightly-folded leaves—the first bud of the bean plant!

**The radicle.**

We remember finding on the surface of the seeds a bump, concerning which we were before left in ignorance. On closer examination it will be found that a second spike underneath the bud causes this bump. The bud will grow upwards, but this second spike is doomed to go downwards into the ground. We have discovered, in fact, the future root ("radicle"). His smooth pointed tip will bore through its prison wall, and then what wonderful thing will it do next? The seeds were sown all ways up, and how will he know which way to go? If he continues straight on he may find himself in the open air. On the other hand, if a seed be sown topsy-turvy, what is to prevent the poor benighted little bud from losing its way and going for ever downwards through the soil like the Marsh King's Daughter? We must watch and try if we can detect the guiding influence that draws the bud upwards and the radicle downwards. Perhaps later on we may be able to answer these questions. Perhaps, on the other hand, we may find that they are unanswerable, that we have stumbled across one of Nature's mysteries.

**Seed leaves.**

If we continue our search still further we shall find between bud-point and root-point a couple of stalks; serving to attach the fat white bodies, between which the plantlet lies embedded. Perhaps, if we carefully unfold the great heavy things and raise the head of the sleeping bud upright between them, somebody may be sharp enough to take a hint from their position and exclaim: "What queer *leaves!*" But you have seen equally queer leaves before on . . . bulbs! And they served an equally good purpose as store-houses of food for the plant. But because our seedling shall soon have plentiful true leaves and roots to work for it, it is dependent on two store-houses only, instead of the number which compose a bulb. Let us compare some of these store-houses. Those of the chestnut, hard though they be, are of the same mealy nature as the bean leaves, and show a rough central dividing line where they are joined as inseparably as Siamese twins. We shall have to watch very closely if we wish to see how the poor squeezed-up little bud finally manages to emerge.

**Leaf-like seed leaves.**

Each sycamore seed has a non-splitting case to itself (*cf.* cereals), where it is kept snug to the last by a warm, fluffy lining. No wonder the seed-coat need not be so tough and thick as that of the chestnut. Now for fun! Here are seed-leaves which we can really unfold—thin rolled-up green ribbons which we might take for true foliage leaves, only they are so unlike those which come on the sycamore later. They do not strike us as being very heavily stored with food, and we look in vain for their dependent bud. We might almost suppose that the clever little thing has put off appearing on purpose, and has said to itself: "There is not enough food for me yet, I'll give these lazy seed-leaves the start so that they may make up for lost time; they shall uncurl above ground, and there do double duty both as store-houses and true working leaves, with my root assisting them; then, and then only, shall I poke up my head."

It will be clear now why the green ribbons are so like foliage leaves. They have to make up above ground for what they have failed to do underneath. Radish seeds will be found in a similar plight; but they are rather too small for examination, in spite of the simple roundish shape of the seed-leaves. (By the way, they are not in the least like later radish leaves, either.) Which child can suggest a suitable way of packing them within the narrow compass of a seed coat? Dame Nature allows no waste of room, and cleverly places them face to face, doubled together over the rootlet. Presently we shall discover how they manage to scramble out, and also what they do with their cast-off garment—for you do not suppose it remains behind in the ground?

**Summary.**—A bean is composed of a pair of extremely thickened and fleshy "seed leaves" born above a "radicle" or little root, on an embryo stem, and enveloping a bud. Chestnut seed leaves are united, while those of the sycamore and radish are comparatively slender and perform the functions of foliage leaves—the primary bud not appearing till they have unfolded above ground and until the radicle has sprouted. In every case the bud depends on the seed-leaves for nourishment.

**Art.**—Illustrate log-book by diagrams to show various ways leaves fold in the seed.

# 37.—SEEDLINGS (3).

*(FOURTH WEEK IN JANUARY.)*

**Root-descending portion of the plant.**

We have some interesting things to find out to-day. Another week has passed. Let us see if the roots have managed to find their way down into the soil in spite of our having sown many a seed topsy-turvy. Consult the radish seed in pots. In every case it will be found that the root has its wits about it. If the seed lies aperture downwards, there is no difficulty—the root grows directly into the soil. But if the seed lies reversed, then the root makes a graceful bend over and dips downwards; for it knows that if it went straight on as its neighbours did, it would come to the surface of the soil. Nothing seems to puzzle this precocious baby root. If any small stone or other obstacle lies in the path, it curls round out of the way, always taking the shortest cut possible. What about the seeds left on the surface? Here the root feels its way close to the level at first, but presently the tip dips into the soil and disappears. It has found that it does not pay to avoid the trouble of digging into the soil, for the latter contains the moisture which is one of the necessaries of life.

**Moisture absorbed by root-hairs.**

How beautifullv the seedling's root is clothed with delicate silky "root hairs"! (these are easiest to observe in the specimens sown on sawdust and cloth). Notice their earliest aspect and appearance. Does the root ever seem able to do without them altogether? Their business is to absorb moisture for the sake of certain important articles of plant diet contained therein. They suck the grains of soil so tenaciously that you will probably break them in trying to pull up the roots of full-grown plants. Here the root branches are bare of hairs at the tips, smooth and well pointed like awls for boring on into new feeding-grounds. So strong are they, delicate though they look, that you see even stout cloth is not too tough an impediment.

**The stem-ascending part of the plant.**

Now let us see if the stem bearing its bud is as clever about finding its way as we have seen our little root to be. Yes, surely and certainly does it make for open air and daylight, undeterred by often having to make queer shifts, even stooping in order to rise.

We have already learnt about the respective duties which require this contrasted growth, the stem being always the ascending, and the root the descending, part of the plant.

**Protection of primary bud** (ARCHED STEM, CLINGING SEED-COAT, ETC.)

We have constantly remarked how the more tender parts of plants are protected by the stronger. Which of you notice contrivances for protecting the seed-leaves, and, together with them, the first and most important bud of the plant? Of course, to begin with, the seed-coat covers all, and the seed-leaves are doubled down face to face over the bud, and do not immediately unfold when the seed sprouts. Indeed the bud now takes the lead, as though it were stronger than its store-houses, pushing through the soil by means of its hunchbacked stem, and drawing them gently after him. See how tough and red the stem becomes where it humps into this strong arch. Bridge-like, it can bear a heavy weight of soil such as would break an upright bud. (The sprouting stem of the winter aconite is a beautiful illustration, on a large scale.)

The class will next notice what various plans the seedlings adopt in order to wriggle free of their coats. Sometimes, when the seed lies aperture upwards, the swelling stem forces apart the edges of the seed-leaves; these in turn split the seed-coats, and they drop off backwards.

In other cases it is just as if children clung to their nurse's apron strings—the seed-coats hang on, night-cap wise, long after the stalk has finally unbent and the ruddy backs of the seed-leaves are exposed to wind and weather. Yes, perhaps the young plant would like to be more independent, but this is not allowed. The fussy old seed-coat it is, which, afraid of harm, hooks over the edge of the seed-leaves by a little sticky membranous claw, just where they fold lengthwise on their mid-rib. Not until the innermost folded seed-leaf stiffens its back, declares independence

and tosses its head away from its brother leaf, does the old seed-coat deem herself superfluous and drop away.

The children may wind up the hour by sowing cucumber seeds.

**Summary.**—The stem is the ascending and the root is the descending part of a plant, and this is manifested by the growth of even the youngest seedlings. The tip of the root is adapted to piercing the soil, and the root hairs immediately behind it absorb the moisture. The seed-leaves of some plants (*e.g.* radish) are protected in their passage through the soil by being folded downwards towards the tip of the bent stem which does not unarch till well above the soil. One seed-leaf is, moreover, folded inside another, and the protective seed-coats do not as a rule drop off till they have seen the seed-leaves safely unfolded above ground.

**Art.**—Illustrate log-book with present aspect of seedlings, including outline of a seedling which has sprouted upside down. (Omit very minute specimens.) Note the variously clinging seed-coats. If sprouting aconites are to be had, they may be substituted for above studies, being large, easy, and beautiful to draw, and illustrating the points of the lesson.

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## 38.—SEEDLINGS (4).

(*FIRST WEEK IN FEBRUARY.*)

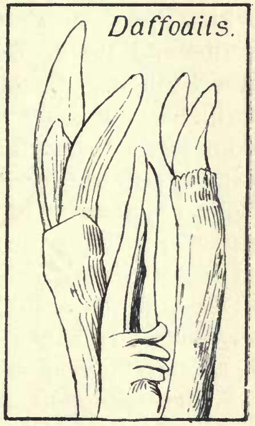
**Rapidity, weakness, and pallor of growth in the dark.**

Compare radish seedlings grown in the dark with those grown in the light. Neither leaves nor stem show a tinge of green, unless, indeed, some stray gleam of light thus betrays its admittance—all are yellowish-white. The seedlings of the dark look like the ghosts of their sturdy out-door brothers. They resemble children of our cities who have lived dim days under clouds of smoke, tall enough perhaps, but very pale, and so slim that they hardly carry the weight of their seed-leaves. If the class noted on which day they first appeared

above ground, it will be possible to measure and see how many inches have been put on in how many weeks. Compare the comparatively slow growth of sunlit seedlings and their "glad bright green." Sunlight alone imparts verdure (Lesson III.), underground leaves and stems being more or less blanched like forced celery.

**Position of leaves regulated by light.**

Another peculiarity of our pale seedlings lies in the fact that the seed-leaves have not opened out but remain pressed face to face. The children may remember that leaves are arranged on the branch so as to obtain the greatest possible amount of light, also that the lower boughs of trees often bend upwards to reach the light, that they die if they cannot succeed in their quest, and many similar circumstances. When young leaves first appear above ground they are too delicate to stand glare or heat, having been hitherto accustomed to darkness, and so they hide their faces. Compare how the leaves of bulbs come up edge to edge, or one within another, thus forming spikes, tip sunwards. As soon as our seed-leaves are hardened to their new conditions, they go on the opposite tack and spread out in order to catch as much light as possible. The seed-leaves growing in darkness, however, have nothing to gain by shifting their position, so save themselves the trouble.




**Light necessary to preparation of plant food.**

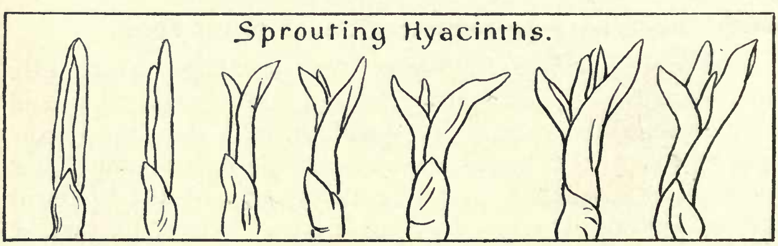
Let a tiny ray of light reach our seedlings (by slightly uncovering their habitation). Before long they will all unfold their leaves and turn eagerly towards it, each striving to grow right through the bright chink. At the same time their colours will change from white to green, and the bud will at last appear between the seed-leaves. Why "at last"? Because the seedling spent its strength to produce that long stem—growing so fast, so fast, because it always hoped to reach the light. If it were a human creature we should say, "What touching faith and instinct!"

**Growth at the expense of reserved force.**

Perhaps the children may feel puzzled if they remember clearly the early lessons which explained that not only verdure, but growth, requires sunlight, and that the most favourably situated leaves (at the tips of the branches) produced the largest buds. But then our pale seedlings do *not* produce buds, and their leaves are small and starved. Feel how extremely light each seedling is. In spite of their rapid growth we are again brought to the conclusion that sunlight is used in the preparation of plant food. Under its influence the leaves absorb raw materials out of the air, which meet in the cells other materials sent up from the roots, and there undergo changes for the sake of the plant's nourishment. Certainly these processes can continue in twilight, but only slowly, and in utter darkness they are completely arrested. Perhaps, if you know how much more rapidly potato tubers sprout in the dark than they do in the light, an answer to our problem may suggest itself. Rapid growth, without sunlight, can only take place at the expense of *reserve stores*, such as exist in tuber bulb and seed-leaf; and, indeed, if we require a proof, just weigh a starved radish seedling. Is it any heavier than the original seed from which it sprang, and on which it has lived ever since ?

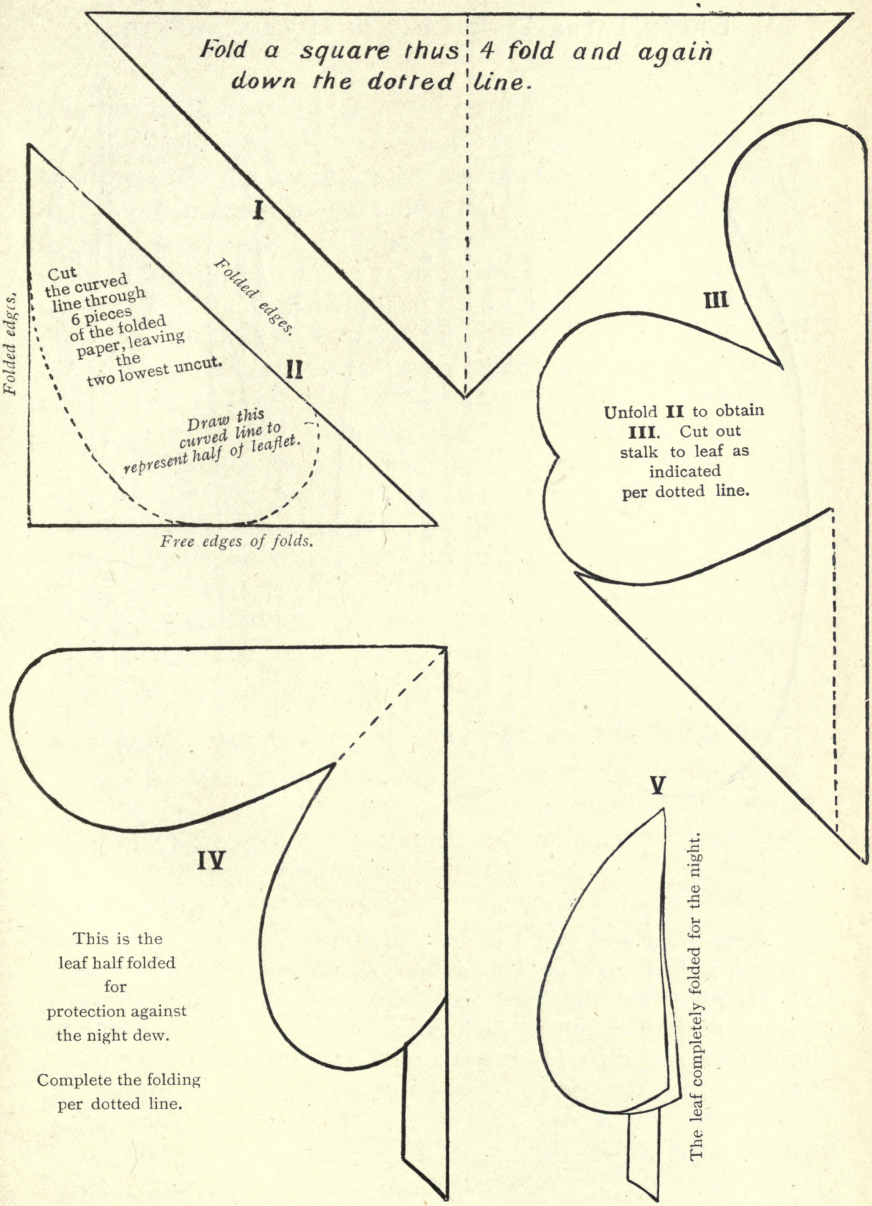
The reflection suggests itself in connection with these seedlings, that we cannot take more out of life than we put into it; in other words, neither management nor device, but his own vital action only, may increase, to each man, his own store of blessing and opportunity.

Let a few more radish seeds be sown at the end of this lesson.



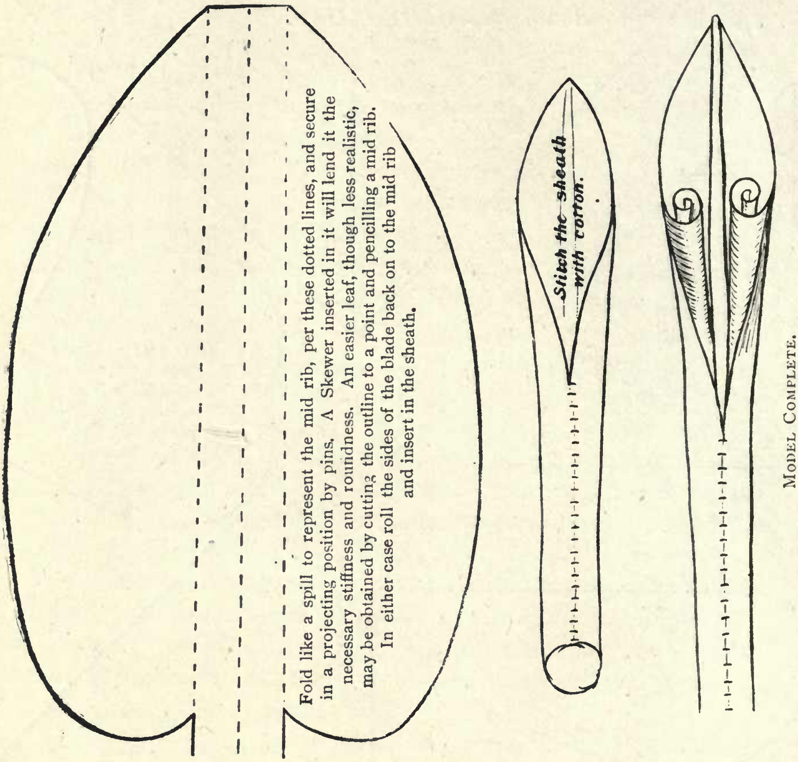

**Summary.**—Sunlight is required by leaves for the absorption and preparation of plant food, and the green colour of plants is dependent on its action. Seedlings which

## Shamrock Leaf *(Green Paper)*.



germinate in darkness can only grow on material stored in the seed; they do this very rapidly and become extremely attenuated in form.

## Green Paper Dock Leaf in Muslin Sheath.




This sheath of book muslin, 4 inches long by one inch in diameter, may be stretched with a pencil to facilitate entrance of the leaf. But it would be easier to work on a far larger scale than the diagrams.

**Art.**—Cut and fold (see the diagrams, page 101) a shamrock leaf as it first gets up out of the ground and as it goes to bed at night—hiding its face from the cold night dew. Also a young dock leaf rolled backwards, on each side, towards its protruding mid-rib. Insert it in a protective-sheath. (Book muslin fastened with stitches or stamp-paper.)

# 39.—SEEDLINGS (5).

(*SECOND WEEK IN FEBRUARY.*)

**Grades of ambition in seed-leaves.**

The seedlings are all now well up, and it is interesting to compare the different kinds of seed-leaves. Is it not strange that the first leaves of the radish and the sycamore, in spite of their resemblance to ordinary foliage, should be quite different to all following leaves? Perhaps, before long, we shall learn what forces compel their outlines. Meanwhile, look how thick and fleshy, in comparison, are the bean leaves; and those of the scarlet runner even more so—they have hardly got any leaf stalk at all. Those of the scarlet runner lie on the surface of the soil, but those of the bean, trying to ape true leaves, are a little raised. Foolish ambition!—to wish to *look* like leaves when they are not asked to do the *work* of leaves—they are just fat store-houses. Yet the poor stem struggles to hoist them up from below, while his more fortunate brother, on the scarlet runner, grows at leisure instead, *above* the seed-leaves. Even from their earliest baby-hood within the seed these stems betray their respective destinies.

**Necessary elongation of chestnut seed-leaf stalks.**

Scarlet runner seed-leaves may seem strangely misnamed, but still they are much more leaf-like than those of the horse-chestnut, which we vainly tried to separate some time since. Remember how we wondered whether the bud did ever find its way out from between them? Dig up one of your chestnuts and behold! a long white worm-like shoot has found its way down into the soil and we know it must have been produced from the rooting end of the stem, though where the stem leaves off and the root begins it is not easy to say. Close to where they have emerged, a slit has now appeared, and through its mouth, only see! the hidden bud has slowly reared its head. We naturally look for the cradle in which the adventurous young thing, like other buds, must have started life, and at last we find the leaf-stalks. They have grown

wedge-like within the chestnut, have split it asunder, and driven the jealous guardian-leaves apart, thus obliging them to let the treasured bud grow free!

**How the cucumber got out of prison.**

Each kind of seedling seems to have a different story of clever contrivances, to tell about. Watch the sister leaves of a cucumber seedling and listen to their tale. (You will notice that they are a degree fatter than those of the radish, but resemble true foliage all the same.) They seem to say: "How clever we are! Most of us have left our fussy old seed-coats behind us in the ground; we cannot imagine how the radish leaves put up with them so long. But then the poor things look spiritless from the first, folded back as they are over their stems; whereas *we* lie in the seed cheek to cheek, ready to jump up the moment Mistress Spring bids us awake! Then our knowing little stem, as soon as he has an inch or two of root beneath him, comes to our rescue like the good brother he is! He catches the old seed-coat with a claw (which you can see if you look, just about where he starts), and he pegs her down fast and won't let her follow us. Then we scramble out from her shelter backwards as quick as ever we can, and the stem pulls us up after him while he grows. To be sure, not *all* leaves have such a kind brother! Sometimes he just won't trouble, the peg lets go and up come the poor twin leaves pinned together fast by their obstinate old seed-coat, and they cannot open to sun and air without fighting her. And yet she was so good to them once, keeping them warm and snug. What a terrible fix to be in!"

Perhaps we may find out in time that equally exciting adventures happen to our other seedlings. But you must find out for yourselves. The seedlings can tell you their own story better than any teacher. Look at the strong back of their doubled-up stems, what a tug they seem to be having, dragging the seed-leaves free of coats and soil! and what an unexpected size are these leaves when they finally straighten up and expand!

**All our seedlings are of outside growers.**

Now we want to see what seedling inside growers may be like, so we shall sow some wheat and onion seed, first soaking it in hot water to hasten germination.

Sow some onion seed also between blotting paper and keep it damp.

**Summary.**—Seed-leaves exhibit various degrees of resemblance to foliage leaves. Those of the bean being more leaf-like than those of the scarlet runner are raised above the soil by elongation of the stem beneath them, a peculiarity which is visible in the embryo. Chestnut seed-leaves, being united, are thrust asunder by the growth of the leaf-stalks, and so the bud emerges. The stem of the cucumber seedling grows an underground peg, which pegs down the seed-coat and prevents it from hampering further growth of seed-leaves.

**Art.**—Draw sprouting beans, scarlet runners, cucumber and chestnut.

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## 40.—SEEDLINGS (6).

(*THIRD WEEK IN FEBRUARY.*)

**Size of seed-leaf ultimately dependent on size of seed vessel.**

Seed-leaves seem to be twins in every respect, except that one is often smaller and on a shorter stalk than the other. Why this inequality? Examine the latest sown radish seeds. As we have before noticed, one seed-leaf folds right over the other, and both fold over the stem. Now if the outer were the larger and the longer stalked, the edges of the inner would project. "And why not?" you may ask. Dame Nature replies that you are all spendthrifts, asking for larger seed cases; or, like spendthrifts again, perhaps you would perform a very wasteful piece of economy, and diminish the number of seeds in order that each may produce a larger and more boastful seedling? Just fold a piece of paper, and cut out two giant seed-leaves, stick them into a pencil-holder by way of a stalk, with a piece of pencil wedged in to keep them tight, and fold them down as the seedling does. Allowing for the clumsy materials, your big model will teach you more than many words.

**Heart-shape due to pressure of seed-coats.**

Now we return to a former query. Is the heart-shape of these leaves due to hazard? Hardly likely! When the baby stem splits open the seed-coats and starts growing at a great pace, the seed-leaves naturally wish to follow its example. But they are very tender things as yet, and on every side they find themselves hemmed in by tough walls, except in the one spot where the stronger stem has rent an opening. Here then, at their lower outer edges, they get a chance to expand; but their heads are held fast by the claw of the seed-coat, and they show the consequent dent ever after.

How little accident we find in nature!

**Evolution of leaf forms.**

Compare with these seed-leaves the simply outlined true foliage of the young radish, with its slightly notched and crinkled edge. But already the second or third leaf show a tooth or two, and these become wider and less pointed and increased in number till the leaves are almost "compound" (divided into leaflets) at the base. A narrow strip of leaf tissue, however, still connects each lobe, forming the stalk into a water channel rootwards.

Now we reach the latest stage of all, when three separate leaflets form. Yet the only poor shadowing of this ultimate shape lay in the wavy margin of the first leaves; although, if we compare the veinings in the light of after knowledge, we may discern where divisions are one day destined to arise. Thus Nature seems to foresee her own ends, and is content to attain them very slowly.

**Growth of stems throughout their length.**

Not only do radish leaves change shape but position also. The two first foliage leaves oppose each other, the stem does not lengthen out between them. But the following leaves are alternate. Does Nature hurry over this change any more than she did over the other?

We know that young stems are as impatient as most young people and grow quickly. Let us see how fast by inking off spaces—say half-inch apart—along a young shoot. We shall find in a very few days that the pen marks are further apart; also, that, though a shoot grows most in its

youngest—*i.e.* uppermost part, it also grows in the intervals between the lower leaves. So the whole growth keeps time together and yet each part moves according to its age.

**Roots grow at the tip only.**

Do roots grow in the same way? They bear no leaves and no buds—the branches come in an irregular, haphazard way; but do they grow throughout their length? We can easily mark intervals on the clean horizontal roots of seedlings which have sprouted between folds of blotting paper. We find that the lowest mark will soon be left far behind the tip of the root, but that the other interval remains the same. A root, in fact, grows at its tip only. What become of the root hairs on the oldest part? Does one ever see a thick root clothed all the way up?

The lesson may be wound up by marking onion seedlings in blotting paper with *marking* ink. Ordinary ink will run.

**Summary.**—The unequal size of the radish seed leaves conduces to economy of space in the seed. Their big basal notch is caused by the clutch of the seed-coat at an early stage. The first leaves of both radish and bean are entire, their typical form being very gradually acquired. Stems bearing alternate leaves may produce their first pair opposite. Stems grow throughout their length, though most rapidly in the upper intervals. Roots on the contrary grow at their tips, and their branching is quite irregular.

**Art.**—Draw sprouting radish. Illustrate advanced state of other seedlings. Make, if possible, a series of outlines, showing the development of shapes in radish and bean leaves.

# 41.—SEEDLINGS (7).

*(FOURTH WEEK IN FEBRUARY.)*

[Some wheat and maize seeds should be ready, softened by soaking for dissection.]

**Storage of food outside embryo.**

Where is the embryo plant in an onion seed, or wheat, or maize grains? These seeds are all filled with a white matter which resembles the substance of seed-leaves in (for instance) bean and chestnut. But it is solid throughout, and there is no sign of a stem to show that two seed-leaves have joined together. What may the little white body be which is coiled up in the onion seed with its back to the rounded edge? We have seen nothing like this wee thing before. Correspondingly, we find in the wheat grain a little wrinkled knob at the bottom of the rounded side, and on dissection we find here a body quite different to the surrounding white matter. Whatever can it be? In the maize grain there is something very similar situated against one of the flat sides. All these mites are evidently made up of several parts, but they are too small to be seen clearly by the naked eye, and we look in vain for the seed-leaves and all that we have been accustomed to find inside seeds.

Now if we rootle about amongst sprouting grains of wheat we shall find their seed-coats left behind, but still attached to them, in the soil. Squeeze them and a lot of white stuff comes out; it reminds us of the solid substance we found before, and certainly cannot be part of the young plants, for are they not growing there before us? Where-ever have they sprung from if not from those tiny mites of bodies which puzzled us so just now? And, indeed, if we were to examine one of them through a magnifying glass we should discover that it is indeed a baby plant—just a germ, in fact. Furthermore, if we look at the seed-coats of older seedlings we shall find them quite empty—who can guess what has become of the white substance? It has been used up by the plantlet, and turns out to be the same substance as that stored by the fat leaves of other seedlings. Only here it

is stored *outside* the embryo plant. When people first studied seeds they called this white food by a word meaning "white of egg," because it surrounds and feeds the germ which they likened to egg yolk. As it nourishes the young plant, so also does it sustain man, and in storing supplies for its offspring, the humble little corn plant gives us our most valued food. In beans and peas we find the same kind of nutriment stored in seed-leaves. So, also, in all manner of nuts.

**A single seed-leaf sheathes the stem.**

The further history of our onion seedling shall be traced in our next and last lesson on this subject. Meanwhile for a puzzle: let us try to find the seed-leaves of wheat and maize plantlets. (They grow larger than the onion and are easier to examine.) Remember how the leaves of wheat and other corn sheathe the stem. Here, in extreme youth, we may expect to find the intervals of stem are very short, the leaves appearing to grow one out of another; and, sure enough, the green spike of the sprouting seedling will be found to consist of a number of leaves which thus shield and enclose each other. The outermost leaves are not much developed, but still we search in vain for seed-leaves such as we found before. Well, we must look for the very first leaf which shows at the very earliest stage of germination, and conclude that it has decided to battle through without a twin sister. Indeed, it seems quite able to do all the work that is required single-handed; and, having no food to store, it contents itself by completely enwrapping the bud. When this begins to sprout, it remains unchanged in aspect and office, still enclosing the first leaf and the short stem; not protecting merely, but transmitting the food which it carries down its whole length of back.

**Several equal roots to each seedling.**

What difference is there to be found between the roots of the corn seedlings and those previously studied? In cucumber or radish a single root is first produced from the stem base and this afterwards branches; but the corn rootlet is always accompanied or followed by others of equal strength. Therefore we never find a tap root, for this would be formed by a primary root which took the lead to the last. Notice

also that these young corn roots are veritable pioneers; they have to burst their way through the basal portion of the seed-leaf and outermost leaf of the stem. Once through, they work like brothers for the common weal—by being many and long enough they profit the parent—by not being too many or too long they profit the neighbours who must have room to grow and thrive as well as themselves. What a lesson in moderation and public spirit!

**Summary**.—The food material for a seedling may be stored outside the embryo instead of within the seed-leaves. Corn seedlings have only one seed-leaf. It is very minute and does not change in germination, but still encloses the base of the stem and its lowest leaf. Several roots are produced together, and these have to break through the seed-leaf and part of the first (inefficient) foliage leaf.

**Art**.—Brushwork studies of corn and other seedlings in the log books.

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## 42.—SEEDLINGS (8).

(*FIRST WEEK IN MARCH.*)

### Single seed-leaf of onions.

Now let us return to the history of an onion seed, which we left as such, and which we must now examine in the act of sprouting. The slender loop which first appears reminds us of the doubled-up stem which we have so often watched in the case of other seedlings. But this nature of the thing is not to be taken for granted. See! day by day as the loop heightens, one side of it thickens and tapers to the other until it resembles a whip handle with the lash caught firmly in the soil. Now our suspicions are aroused, for we have learnt that stems only thicken by means of buds, never taper without a cause in this most curious fashion. The handle at last gets quite bent with tugging, and up comes the whip-lash capped—if the soil be

yielding enough to let it go—with the seed-coat. We know how the fussy old body is always afraid to let its nursling leaves go free; and we know, too, that in corn plants only a single seed-leaf is produced. Perhaps the whip-lash is a seed-leaf—only it looks so very unlike a leaf at all!

**Tubular onion foliage-leaves.**

If you remember the ordinary foliage leaves of older onions, are they not round and tapering? Look at them, and you will find that the roundness is caused by the edges of the leaf having joined together with just a little slit to allow the next leaf to emerge. There is probably a very good reason for this queer behaviour. Many grasses are folded along their mid-rib, pine needles and the leaves of heath roll up, and thus the upper and most delicate surface of the leaf is protected alike from cold and heat. Who knows whether these soft, fresh onion leaves might not turn brown and wither were they exposed face forward to the summer sun? To return to our seed-leaf. A few days after it has straightened its back, what happens? The first true leaf must get out somehow, and, accordingly, a slit appears towards the base of the seed-leaf. Where does the new-comer join its stem? If we continue the slit downwards with a pin we shall find that part of the seed-leaf is under-ground and that such a thing as a stem is hardly to be seen at all. The nourishment from the seed-coat (borne aloft in the air) has to travel all down this long seed-leaf in order to reach the foliage leaves, which remind us of a Yankee sucking lemon squash through a straw. When the poor old seed-coat is sucked quite dry it drops off, as we have already seen.

**Bulb composed of leaf foundations.**

We have seen that the stem of the seedling is very short, and it remains so until the time of flowering. How then is the bulb formed? It is composed of the overlapping bases of the leaves, and this is what we eat. In time they store food and so become fleshy. All bulbs grown from seed gradually form in this way.

**Roots similar to those of corn.**

There is a preliminary tap root, the length of which we may ascertain by measuring. It does not remain alone in its glory for

long; it is soon equalled by two brothers, who start from the same point and overtake the pioneer. Onion seedlings, therefore, resemble those of wheat and maize in having a single seed-leaf, several roots, and a store of food *outside* the embryo.

**Characteristics of inside growers.**

To which class do all these plants belong, inside or outside growers? Since to the former, we may ask whether the characteristics above enumerated are peculiar? The method of food storage certainly is not. For many outside growers (*e.g.* potato and pæony) produce seeds in which the food lies outside the germ. Several roots instead of one only is, however, a fairly constant trait. The really important distinction is that of a single seed-leaf instead of two. This holds good with so very few exceptions, that the two classes have even been named by words long to use and difficult to learn, but meaning "one seed-leaf" and "two seed-leaves" respectively.

**Summary.**—One seed-leaf is characteristic of inside growers and two of outside growers. The production of several equal roots instead of a single primary one is typical of most inside growers, and the two methods of food storage are common to both classes.

(The children should be taken into a garden and made to tell which class every sprouting vegetable and weed belongs to.)

**Art.**—A dainty brushwork design may be based on all previous studies (in pen and colour) of seedlings and seeds. Outline onion seedling in logbook.

# 43.—APRICOT BLOSSOM (1).

(*SECOND WEEK IN MARCH.*)

**Flower-buds open before leaf-buds.**

Is there any tree already in flower, or in leaf either? Is the apricot in leaf? Can the children think of any other tree or plant of which the flower ventures out before the leaf? What about the chestnut? We remember the buds, and we know that they give a negative answer; leaves are packed up with the blossom, and if the apricot buds also had contained them, they would have burst out along with the flowers.

**Mixed buds.**

See how the apricot buds are produced in triplets, two fruit buds to one leaf bud in each group; and, as the children may explain, there is a difference between these two kinds of buds which may be told at sight. The "mixed buds" of the chestnut tree are a third variety.

Section of Apricot Fruit-bud (much detail omitted for clearness' sake)

**All three kinds of buds are scaly.**

Before dissecting a flower bud, let the children name the parts which compose a complete flower. Can these little hard brown things of the outermost circle really be sepals? No, for the leaf buds are similarly clothed; we remember very large scales on the chestnut twigs. Mixed buds, leaf buds, fruit buds—all have this scaly covering.

**The flower complete in its bud stage.**

Let the children next cut the apricot bud downwards, and make out the different parts which are packed away inside. The white petals are there—folded like sheets beneath the blankets or sepals. The stamens are doubled over round a tiny pistil which is all complete, though, perhaps, too small for the natural eye to see. A very much magnified bud section ought to be drawn on the blackboard for the sake of clearness.

**Coloured sepals.**

Apricot sepals are bright pink. The children must not think that petals monopolize bright colours, or that sepals must always be green or brown because they often are so. The outer leaves of the tulip may at first seem a similar case—they were coloured and united with the inner ones in the task of attracting insects; but there is a difference here. The sepals bend backwards as soon as the flower no longer needs blankets, and allow the petals to follow their own business.

**Foundation of the outer flower circles.**

Who can tell the great difference between the construction of this flower and those previously studied? Let the teacher, or if possible one of the pupils, draw a tulip or a wallflower from memory on the blackboard. Where do their sepals and petals spring from? The cucumber sepals and petals join in a tube at their base; but this arrangement, also, is different to what we observe in apricot blossom, where sepals and petals half peel, half tear, off a single tube which does not seem to be entirely formed by either of them. The sepals peel off outside, the petals and stamens spring from within, the tube rim. In the cases of both wallflower and tulip, on the other hand, the flower circles all sprang from the enlarged top of a flower stalk.

**Summary.**—The apricot is the earliest fruit tree to blossom. A brace of flower buds is usually grouped with a single leaf bud and opens before the foliage. They are all protected by scales and the inner parts of the flower by tough

coloured sepals, which bend back when the flower opens. The flower stalk terminates in a cup shape, from the rim of which spring the three outer flower circles.

**Art.**—Outline flower and its attachment to the twig. Outline every portion of the flower separately. Guide to ultimate design.

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## 44.—FERTILIZATION OF THE APRICOT (2).

(*THIRD WEEK IN MARCH.*)

**Position of the seed-case.**

We saw in the last lesson how the tip of the flower stalk forms a tube or cup. Let it be split open and behold! We shall find, growing out of its centre, a hairy seed-case snugly stowed away.

What would this little seed-case have become by and by, if we had not gathered the flower? Let us learn what we can about its strange transition to yellow fruit.

**Self-fertilization depends on three things.**

What must happen before the seeds (and consequently the seed-cases) may begin to swell and ripen? They must be fertilized, and we know there are three ways by which this can take place—self-fertilization, insect or wind fertilization. We can pronounce on these three possibilities by examining—(1) The relative length of stamens and pistil; (2) The position of the flower, whether hanging or upturned; (3) The respective ripeness of stamens and pistil. If the pistil gets sticky before the pollen bags burst or *vice-versa*, the flower cannot possibly fertilize itself.

**Outer stamens as tall as pistil.**

Now as to the first point. Are the stamens all of equal length? No—the inner are much the shorter, and are joined to the flower tube slightly below the outer stamens. What about their position? Those outside bend back so that they

cannot touch the pistil tip, although quite the right height to do so. The inner stamens bend over the entrance of the flower cup as if on guard, so that we cannot see inside it. Do all the flowers agree to this description ?

**Flowers vary in position.**

As to the second point: the position of the flower is not always the same. Some turn straight upwards to the light, and others sideways, in which last case self-fertilization could perhaps come about by the pollen falling from the outer stamens on to the pistil. But this brings us to our third point: whether stamens and pistil ripen together.

**Appearance of a ripe pistil tip.**

If we compare buds with full-blown flowers, we find that the young pistil tip is pale yellow. It darkens with age, and becomes sticky during a period which probably covers a portion of the time when pollen bags are shedding their dust. Look and see. The pistil is usually bent, hanging head downwards. Does it ever thus reach the pollen ?

**Self-fertilization possible, but cross-fertilization aimed at.**

We may conclude that self-fertilization often happens either owing to the sidelong position of the flower, or to the bending of the pistil. But do the children suppose that the flower prefers this plan to any other ? We can tell whether it wants to be cross-fertilized by watching to see whether bees visit it. Also, if we can detect apricot blossom very easily from a distance, we may surmise that it does not put on showy clothes for no purpose.

**Bees come for honey and pollen.**

Apricot blossom cannot but attract attention at a time when there are but few other flowers out, so they have the insects pretty much to themselves. However, only bees, you see, come out so early in the year, and then only on sunny days, lured out by the full spread signals. It is easy to see the great yellow lumps of their honey wag on each hind leg.

**Pollen bags intercept the bees.**

Where do the bees find the honey ? It is right at the bottom of the flower cup. Perhaps those orange spots show

the way, which is concealed by a barrier of stamens. The bees force their way through, and thus get well dusted.

**Home-made pollen least effectual.**

Probably the bee will rub some of this pollen on to the pistil tip of the next flower, bumping against the down-turned pistil. It will occur to the children that self-fertilization might, with equal probability, be caused this way, but they will remember that nature prefers cross-fertilization, and that, therefore, strange pollen has more power than the other to shoot seedwards.

In short, every apricot flower stands good chances of cross-fertilization, and failing that, of self-fertilization also. Thus the plant secures a second string to its bow, for if the weather is dull there may not be many bees about.

**Summary.**—Self-fertilization is possible either when the flower turns sideways, so that pollen can fall on to the pistil tip; or when the pistil bends down to the pollen bags. Cross-fertilization must, however, take place, as bees visit the flowers for both honey and pollen.

**Art.**—Brush work studies of the flower, and of separate petals. Use white body colour on tinted paper. Or instead of brush work the children may fill in coloured chalk outlines on tinted paper.

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## 45.—BABY APRICOTS (3).

(*FOURTH WEEK IN MARCH.*)

**Fruit either drops or sets.**

We have at a previous stage observed the apricot passing through the middle chapter of its life, and are now in quest of further knowledge regarding the plant. The sepals, petals and stamens, on feeling that they are no longer wanted, shrivel into a brown ring round an equally withered pistil stalk and drop away. You may wonder how they free themselves from the tube, but it shrivels also—the seed case alone remains living

and active. It evidently has set itself to a great undertaking and swells away rapidly. Then it is that gardeners say the fruit has "set." But, supposing the unkind frost has caught the flowers—what then? The seed case has to give up all its hopes and decay also.

**Fate of the flower tube.**

If we examine the fruit a few days after it has set, we find the withered flower tube splits away at its base, and what remains looks like a brown necklace round the future fruit. Presently, as the fruit gets daily bigger, it slips the whole thing—outgrown and worn out—off over its head.

**Single celled seed case.**

If we, at this stage, cut the young apricot across, we shall see a young cell containing two seeds; but one of these looks somewhat squeezed, as if the other were taking more than its fair share of room. Poor little thing, it is doomed to meet with a sad end.

**A single seed survives.**

Who remembers whether a ripe apricot is soft all through? You will say at once, no! there is a stone in the middle. And what was inside the stone? Perhaps you do not all remember the single nut-like seed—as a rule, it is all you can find. He wanted the flower's whole fortune to himself and squeezed his brother to death. Very rarely do you find two content to share and share alike and live happily together. Perhaps it is in the plant's interest that one should do well rather than that two should do badly, only one feels inclined to ask why the second little seed was ever born at all? So far it is one of Nature's secrets—she just won't tell us. But be consoled! Whenever we *do* find out one of Nature's secrets, we invariably are struck by the wisdom revealed. We may trust that it would be the same in this case.

**Changes which accompany the ripening of seed.**

Fruit which has just set is a long way off from fruit which is fully ripe; it will swell during the summer months until at last it will change colour from green to orange; then it will become soft and juicy. It will grow a hard hollow stone

within—a prison for the murderous seed. When all this has happened (about August), the fruit is ready for us to eat; it is ripe. We must put off finding out the final fate of the seed till another lesson—late in the year.

**Difference in seed cases.**

Compare all the seed cases which we have studied. They are uniform in containing seeds, but in hardly anything else. The wallflower case is dry, brittle and hard, and splits to free the seeds. The tulip case splits also, but it is comparatively soft. The melon case is soft within, hard without, and does not split at all. The corn case is so thin, skin-like and inseparable that it may be taken for part of the seed.

Let us now compare the foliage. Some leaves are thin, delicate and soft—others hard, thick or fleshy; nevertheless, they are all made of the same parts, an inner and outer skin and cellular tissue in between; the rhubarb sheath demonstrates this plainly. Now seed cases are composed in exactly the same way, though in many it is impossible to detect the three layers with the naked eye. However, you can distinguish them in the ripe apricot seed case. What lies outside the single seed? First the hard walls of the stone. These must be the inside skin. Then comes the juicy flesh of the fruit. If you could hold a thin slice of it up to the light, just as you would hold up a slice of an orange, you would see the cellular tissue full of juice. Outside is the thin downy skin, the outer skin of the seed case.

We will postpone for another time the discussion why the seed case should undergo such strange alterations; also, in the autumn, when fruits are ripening, we shall return to the difficult subject of structural change in hopes of understanding it then more thoroughly.

**Summary.**—When all the flower parts drop away and the seed case begins to swell, the fruit is said to have "set." The seed case, like a leaf, consists of an inner and outer skin and central tissue; but in the case of apricot fruit the latter becomes juicy when the fruit is ripe, and the inner skin hardens into a stony prison for the single murderous seed.

**Art.**—Brushwork design based on previous studies.

# 46.—PLUM BLOSSOM.

(*FIRST WEEK IN APRIL.*)

**Leaves rolled in the bud.**

You are probably all impatient to know what fate befalls the apricot seed; but we must delay that matter until we consider cherry fruit next month. Meanwhile, let us see whether the plum blossom (which is in flower at present) is, if studied closely, like the apricot blossom which it much resembles in looks, and whether its history, up to the final yet-to-be-known point, is at all similar. The children may first examine the position, order, shape, etc., of the buds. The teacher should note each point, as soon as it is ascertained, on the blackboard, placing the corresponding point about the apricot, side by side for comparison. It will first of all be seen how the leaves of both trees roll up tidily and tightly in the bud, so that not a chink of room is wasted.

How many different ways of packing up buds has any one child noticed?

**Plum buds contain several stalked blossoms.**

Unlike the apricot there are several long-stalked flowers as a rule to a single flower-bud. Nature evidently grudged stalks to the solitary apricot blossoms, which ran no risk of getting in each other's way. Are there any "mixed" buds on plum trees?

**Apricot and plum flowers much alike.**

Let the teacher draw special attention to important points —the position and number of cells in the seed case, and the growth of the flower circles on a tubular rim. If the apricot shares these distinctions with the plum, then the trees must be very near relations, although the flowers may differ in point of colour and in the position (upright in the plum) of both stamens and pistil.

**Varieties of plum blossom: Freaks in the stamens.**

Sometimes a stamen may be found which seems to be almost a petal. Instead of a pollen bag it wears a petal-like

flap on one side, with perhaps just a bad attempt at a pollen bag on the edge of it. We saw similar mimicking efforts in the . . . . . tulip.

**Various length of pistils.**

The comparative length of stamens and pistil varies a good deal on different trees. In some, the pistil is so long that it forces one of the petals open before its time and thrusts an impatient head out of doors. In others, it is shorter than the stamens. Let the children explain how these freaks affect fertilization.

**Number of pistils.**

Now and then, on particular trees, a startling discovery may be made—two, three, sometimes even five or six pistils to a flower; or at least attempts at pistils, for these extra ones are usually not at all a success. Several may be in the middle of the flower cup, but others grow out of its sides just below the stamens. We have seen stamens mimicking petals; these extra pistils sometimes seem to be apeing stamens. We find what looks like half a pistil, half a stamen; the stalk bears a sort of empty pollen bag half-way up and ends in an ordinary pistil tip. Often these pistils have no seed vessel—or an empty one—and at best they are usually poor twisted little things. Even if several set their fruit, there is only room for one to grow.

**Significance of variation.**

Last year, while studying cabbages, we learnt how man transforms leaf, blossom, and bud to suit his purpose, and we saw also how some of these variations might happen in wild plants and be continued if advantageous to Nature's ends.

Here we see instances of more variation, which might lead to some plum-trees being grown in preference to others. Supposing, say, that the long pistil increased a plant's opportunities for cross fertilization, and that fine plums were the result, then the long pistilled tree would be propagated and grown in preference to others.

**Summary.**—The plum agrees with the apricot in important features of growth, flowering and fruit-bearing. It is subject to variation in the comparative length of the

pistils and stamens, and some trees habitually produce flowers with extra and abnormal pistils.

**Art.**—Outline the flower in pencil or on the slates in order that the eye of the children may get accustomed to the shape before attempting colour. Then let them make brushwork (or chalk) studies of flowers entire and piecemeal.

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## 47.—CHERRY BUDS (1).

(*SECOND WEEK IN APRIL.*)

**Colour of leaves and sepals.**

Have the children ever thought what it is "to be in England now that April's there?" Nature's workshop is busy turning out spring garments of all hues for her dear children, "some very red and some a glad light green" (Chaucer's "Flower and the Leaf.") Not only great oaks, "with branches broad laden with leaves new," but even the little cherry tree of our lesson puts on a crimson-shot robe. Then, as the season moves on, the blushing leaves turn green through intermediate shades of brown. Who remembers about the colour of the apricot sepals? (See footnote at end of chapter.)

**Folded leaves and varnished stipules.**

How were plum and apricot leaves arranged in the foliage-bud? Let them be compared with the flat folded leaves of the cherry at the same stage. They pack side by side in the bud instead of one within another, and form a number of slender spikes. At the base of each is a pair of very small twin blades. I hope none of you will be tempted to call them leaves—for why? The lazy things do not cradle a single bud. Bide a wee before condemning; perhaps we shall find they have other work to do. They are called "stipules." It is quite clear that the young buds are very well cared for, whatever the apparent neglect on the part of the stipules. They are covered with the same waterproof varnish which we have

noticed on the big brown chestnut buds in spring, and the leaves shine with it when they first open. If you try to unfold a bud you are resisted by the edges as though they were glued together.

**Large scales to large buds.**

The cherry flower-bud is much more densely packed with blossom than that of the plum. Sometimes it contains a small leaf also, but usually the work of protecting the flowers falls on the scales only, and they are very large accordingly.

**Variety in the scales.**

Pick the scales off one by one—beginning with the outermost—and compare their shapes (especially in the leaf buds). The external hard brown scales resemble those of the apricot and plum, but gradually they grow more leaf-like—larger, brighter—rough and sticky to the touch and hairy for warmth within. Some remain round and much hollowed, others grow out long and narrow; sometimes they are split or slightly forked at the tip.

**Kinship of scales and leaves.**

Finally we come across scales which are not only forked but three-lobed—the "lobe" in the centre is just like a tiny leaf. Fancy a leaf growing out of the tip of a scale! Sometimes its companion at either side outstrips its growth; sometimes, again, it is just the other way about, and there may even be a sort of flattened out stalk between the side lobes and the central one. Next examine some small leaf which has strayed into a flower cluster. The stipules seem to have put off growing until the leaf stalk has widened almost to a blade. Perhaps we begin to see that leaves and scales are simply different forms of the same thing. As regards a scale, stipules and leaf-blade remain more or less undeveloped—not being required. The scale is just a widened, flattened leaf-stalk. If, on the other hand, it succeeds in growing to a leaf-like shape, it does not drop off with its brother scales, but remains behind to do the business of an ordinary leaf. But its stalk, having originally been formed for a different purpose tells us the tale of a former career.

### Various origins of scales.

The horse chestnut, walnut and black currant all possess similar tell-tale blades which have evidently once been leaf-stalks, and which have passed through all stages from plain scabs to scales which have miniature leaves growing from their tips. Perhaps it is clear to us now how foliage is formed by the fibre bundles separating and stretching out to form a framework for the green tissue to build on. Scales, however, are not always formed on a stalk, sometimes they are a modified blade (*e.g.* lilac). In beech and elm trees, such leaf-like scales seem to be dispensed with altogether, their part being played by stipules. Perhaps this is a clue to the function of stipules which seemed to us at first to be lazy things. They sometimes save scales the trouble of turning into leaves by protecting the young foliage and helping it to fulfil its task.

### Scales are the first leaves of the stem.

Scales being really derived from leaves, it is natural to expect that the stem should produce them in the same order as it produces the ordinary leaves. If this turns out to be the case we shall have a final proof of scale origin. Are they then really just young leaves rudely dressed to their task of meeting wind and weather for the sake of younger brothers? The stem allows no space between them; he groups them close to their labour of watching over the opening bud.

**Summary.**—The cherry leaves are folded on their midribs side by side, instead of being rolled over one another as in the plum and apricot buds. At first they are tinged with crimson and share the varnish of the scales. These are of a size corresponding to that of the buds which they must cover, and they plainly show their descent from leaf stalks. Lilac scales are derived from the blade of the leaf, and in the beech and elm the scales take the form of stipules at the base of the leaf-stalks. All are modified for protective purposes.

**Footnote.**—The roseate flushing of the young foliage must not be confused with the redness caused by dots on the leaf-stalks. The dots represent cells of sweet juice, and ants seek them out, just as bees seek out pollen or honey. Do the ants perform any service to the cherry tree in return? Why

yes! We all know how fruit-growers place a ring of lime round tree trunks and resort to various other devices also, in order to prevent the dilapidations caused by caterpillars, etc. The little ants make short work of all such trespassers, and are most effective in police-ing the cherry tree.

**Art**.—Outline, life-size in charcoal, a spray of budding cherry, or this study may be made upon the blackboards.

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## 48.—CHERRY BLOSSOM (2).

(*THIRD WEEK IN APRIL.*)

**Close relationship to plum and apricot.**

When we compared the plum and apricot trees we found that they were closely related. Now it will be interesting to discover whether the cherry is not another first cousin. Let the class dictate to the teacher what are the coinciding features in plum and apricot; he will write them down on the board, and during the lesson we shall see whether the cherry is in agreement or not.

(There are two kinds of wild cherry. (1) The "bird cherry," with small flowers growing in a slender spike, often planted in gardens. (2) The common wild cherry, which is probably an ancestor of the garden cherry, whose flower-clusters it resembles.)

**Cross-fertilization.**

Now let us attend to the flowers closely. What a strong sturdy pistil it has! The bees seem to push off from it when they take flight, much as a diver plunges from his elevation. What showers of pollen from the bee's body are likely to fall at such a jerk! But in any case the bees scramble over the pistil a good deal in quest of honey. So we see the chances are in favour of cross-fertilization.

**Fertilization of the bird cherry.**

Examine the flowers of the bird cherry. It will be found that the pistils are prepared for pollen before the bags burst.

Accordingly, they project a long way from the blossom, so that an insect is almost sure to knock up first and foremost against them, and thus cross-fertilize the flower.

In the absence of insects, self-fertilization can always take place as the stamens are curved inwards. The inner bags ripen, and then the stamens suddenly take it into their heads to rise. Up they go! and strike the pistil in the act.

**Progress of the flower after fertilization.**

The apricot taught us that fruit is sometimes the juicy tissue which develops between the inner and outer skin of the seed-case, but we have still to learn why the plant should go to the trouble of providing us with a delicious dessert. It is certainly not done for our sake; fruit is not merely something for us to eat any more than flowers are just something for us to enjoy. Nature takes thought for her many children besides the human kind. Well, we have constantly seen how the whole plant guards the seeds, and perhaps this juicy tissue develops to the same end. With the view of ascertaining its use let us first enquire what changes accompany its development.

**Change in colour.**

The fruit changes colour, you will say. It turns from greenish-white to bright red (*Cf.* green buds to the glowing colours of expanded flowers).

**Change in taste.**

At first our cherry is hard and tasteless; then it becomes less hard, but remains very *sour* till the colour has quite changed. Then, along with full colour, comes sweetness. We know that flowers advertise their store of honey by means of colour at the period when seeds require fertilization. When the fruit in its turn attains full colour we know that it will drop at a touch; the seeds are ripe, viz. full grown and ready to sprout so soon as they shall obtain suitable conditions, soil and fit weather. To return to our first question in other words, "Why should the tree wish to advertise ripe seeds?" Let us bide our answer for yet a space while we enquire whether wild fruits do the same. Perhaps, if nature is let alone, the seedcase does not swell.

**Wild cherries.**

Yet no! gardens have increased the size of the fruit and

its sweetness, but the wild trees bear after their kind, and the fruit does not rot on the bough. The very name "bird cherry" gives us a hint of what happens.

**Distribution of seeds by birds.**

We may not care to eat the wild cherries. Not so the birds, glad though they be to eat the garden fruit as well, leaving only the stones behind to tell a tale. But have you ever seen wild cherry stones hanging behind on the bough? No, for the birds have gulped them down wholesale. Now if Nature did not wish the birds to eat cherry stones, she would have been at least as clever as our gardeners, and made them too big. Or she would resort to some cunning device such as colouring the fruit green, so that it should not be seen by even the bright-eyed robbers; or she might so sour and harden it that even the birds would pass it by. But if you picture all the fruits which make birds greedy, you will soon conclude that their greed is Nature's aim. We pass on to the reflection that hard stones are quite indigestible, and that therefore they will pass unharmed through a bird's body. Has no one ever heard it said that such and such a plant "must have been sown by birds"? Thus we arrive at an answer to our question at last, why the tree advertises ripe seeds, or, more accurately, juicy fruit. It is as necessary to disperse the seed as it is to fertilize it, and the plant advertises for an agent in either case, repaying one with honey and another with fruit.

The longer we study, the more we shall be struck by the number of ingenious devices whereby seeds may be scattered. It is clear that when the earth is already covered with plants there is not much opportunity for fresh inhabitants, and what there is must be sought for far and wide.

**Summary.**—The cherry is closely related to the plum and apricot. Cross-fertilization is probable. Gardeners have increased the size and sweetness of wild fruits, so as to make them suitable for human consumption; but in the wild state they are eaten by birds, and thus distributed, the hard stone preventing an injury to the seeds.

**Art.**—Chalk or brushwork studies of cherry blossom.

# 49.—APPLE AND PEAR BUDS AND BLOSSOM (1).

(*FOURTH WEEK IN APRIL.*)

**Dress of mixed buds.**

Which of you can tell at sight the difference between a naked apple and a naked pear tree? A variety of distinctions may be noted by the class; amongst others, the slender pointed shape of the pear buds.

These dainty speckled buds repay attention; the scales lap each other over like the slates of a roof, each is brown above and a tender green below. According to the extent of green, so the age of the scale; it keeps pace for a short time with the growth of the bud it must help to cover, fearful of forsaking its duty too soon.

Let us now pull some fat buds of both apple and pear to pieces, and we shall find they are "mixed," containing leaf and flower together. Perhaps we understand now why the scales need not be so tough and warm as those of the cherry—the leaves are additional coverings. Their bases are developed, too, in a scale-like manner, and each is accompanied by two stipules such as we saw on cherry foliage. Notice that these stipules do not originate opposite to each other, but grow with an interval of stem between them like the real leaves.

**Mixed buds terminal.**

Are we sure that *all* the buds on these trees are mixed? The lateral buds are shaped differently and seem to contain leaves only. They are not nearly so forward as the mixed buds at the spur tips. Here is scope for much recapitulation. (Lesson 4).

**How the leaves fold in the bud.**

Do you still remember how cherry leaves and plum leaves are folded in the bud? Here we find another plan. The two sides of each leaf are rolled up separately upon themselves,

thus forming a double tube (*cf.* onion leaves), and each leaf holds itself aloof from its neighbours; whereas we noticed that plum leaves are tucked away within each other's folds.

**Characteristics of young leaves.**

What further care does Nature bestow upon these young delicate leaves? Their exposed backs, edges, the stalks, and the sepals are all covered with a white woollen blanket. Who has not noticed the pearly aspect of apple buds against a dark sky? Later on this blanket is no longer required and it shrivels away. The inner sides of the leaves are shiny, reminding one of the far stickier cherry foliage. The latter, on the other hand, is comparatively hairless, and in time loses its green just as the apple and pear leaves lose their wool. Note bright tinting here and there, a tendency of young exposed growth. Rosy cheeks, "fearing not and caring not, though it be a'cold!"

**Characteristics of the flower clusters.**

Examine flowering shoots of apple, crab apple, and pear. What is the difference between their flower clusters? The pear blossom springs from the sides of a common stalk. How then does it differ from a flower spike—such as barley? In this way: that the lowest flowers have the longest stalks, so that they reach the same level, or nearly so, as the upper flowers. If we were to shorten the intervals between the flower stalks, that is to say, shorten the common central stalk, we should have the same flower cluster as that produced by the garden apple. Shorten the central stem still further so that all the flower stalks seem to start from the same point, and we have the crab apple's plan.

**Crab apple—ancestor of the garden apple.**

The crab is the ancestor of hundreds of garden varieties; just as the wild cherry, plum, and pear have given rise to cultivated kinds. How does the crab differ from the garden apple? Just in the same way as wild cherries differ from garden ones. They are sour and small. But there is a great deal more to be said about fruit than just those qualities which cause us to eat it. Wait till the autumn, and we shall have many interesting tales to tell.

**Summary.**—Apple and pear leaves are protected in childhood by woolly coverings on their backs and edges. They are shiny on the inside. Bright tints appear under exposure, such as we noticed on the cherry trees. Flowers are borne in mixed terminal buds. The pear clusters differ from those of the apple by the florets being produced up a central stem. The superficial effect is similar owing to the lowest flowers having the longest stalks.

**Art.**—Outline studies of pear and apple blossom in charcoal on a large scale.

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## 50.—BABY APPLES AND PEARS (2).

(*FIRST WEEK IN MAY.*)

**Seed vessel embedded in flower stalk.**

Let the teacher follow our former methods of comparison with previously-studied flowers. Apple and pear blossoms coincide in important points, but both evidence a more distant relationship to apricot, plum and cherry than exists between themselves.

For instance, apple and pear blossoms are saucer-shaped instead of deep and cup-shaped (like the plum). Can any one discover why this should be the case? Perhaps we had better dissect a flower before starting on surmises. The seed vessel will be found embedded in the tip of the flower stalk (as a cross section will prove), thus reminding us of the vegetable marrow. The flower circles do not crown the seed-case, but, instead, they spring from the walls of the flower stalk which have grown up around it. Hence a comparatively shallow blossom. This doubtless means prosperity to the plant were we clever enough to know all.

**Five cells in the seed-case.**

Let us cut the cup across and count how many cells and seeds the case contains. If we are not too much discouraged by the recollection of that half-hearted two-celled and one-

seeded apricot, we shall expect to find five seeds, in correspondence to the prevailing number of the outer flower circles and of the pistil branches. (It would be a big task to count the stamens which should number a multiple of five.) Well, the apple exceeds expectation, for it produces not five only, but ten seeds—two to a cell. Next time if you help to core apples for a pudding, you will have abundant opportunity for noticing what becomes of cells and seeds in the ripe fruit.

**Cross-fertilization most probable.**

Let us, by examining flowers in different stages, try to ascertain whether they invite bees, or whether the blossom is content with self-fertilization. The position of the pollen bags with regard to the pistil tip will be found to vary slightly in different trees; but, as a rule, the stamens stretch away from the pistil and the branches of the latter (which stand lower down than any we have seen) overtop them. The pollen, therefore, is not likely to reach the right place unless the flower tilts very much to one side. The usual position of the flower ought to be observed; also whether the pollen bags burst at the moment when the pistil is sticky for the retention of dust. Now, the pistil matures *before* the pollen, so the chances are in favour of cross-fertilization. The stamens—let it be noticed—do not all ripen at the same time, and the more mature they become, the more they lean away from the pistil. Their behaviour is peculiar in other respects also: They do not unbend till after the flower has quite opened; but continue making a deep bow to the pistil, which stands erect like a king among an even circle of beautifully-dressed courtiers. The pear stamens are clothed at first in pink, which deepens later on, through crimson shades, almost into black.

**Survival of the fittest young fruit.**

What becomes of all this clustered wealth of young fruit? We have never seen so many ripen; in fact, we know that there would not be room for them. If we look at the fruit a few days after it has "set," we shall find that some youngsters are larger than their brethren; and finally, perhaps, only one of a group lives to old age. The tree cannot afford to bring up such a large family. (Remember the murder of

the apricot twin seed.) No lots are cast as to which of the young apples shall live—success is an award of early zeal. The one who survives gets up betimes and has a start of the others. You may think that, as a solitary flower, our "early riser" is less likely to be found and fertilized than if all were open, the colour (and consequent advertisement) being minimized. But is this so? It is the under side of the petals which are bright pink, and therefore a white blossom surrounded by buds is shown off and likely to be fertilized.

As a rule it is the middle bud which steals this march. (What is the pear's case?)

However, sometimes the outer blossoms have a chance by being first as regards space and light. There is a "survival of the fittest" going on early among the young apples—the strongest lives; the weak-stemmed, insufficiently fertilized or crowded flowers have no chance. (Compare young chestnuts.)

**Summary.**—Apple and pear nearly related to one another and more distantly to apricot, plum and cherry. In all the tip of the flower stalk forms a cup, from the walls of which spring the flower parts in fives, or multiples of five. In the case of pear and apple, however, the seed-case is embedded instead of standing in the flower stalk cup, and it is five instead of two-celled. Cross-fertilization probable. Not all of the young fruit in a cluster attain maturity, but those that are strongest owing to priority in fertilization or advantageous position.

**Art.**—Diaper design of fruit flowers in brushwork, based on previous brushwork studies.

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## 51.—THE STRAWBERRY PLANT.

(*SECOND WEEK IN MAY.*)

[Entire with runners and cleansed roots.]

**Perennials and annuals.**

Do the children remember how long annuals and perennials respectively live? Annual means "one year." Biennial means "two years." Perennial means "through the year"

without limit to the duration of life. We may wonder at the unequal span allotted to different members of the same family —we know that sweet peas die, while everlasting peas live on and on through the winters. Some cabbages are annual, whereas others are biennial. Now who can tell whether a strawberry plant is an annual or a perennial? Do not give an opinion hastily or speak from memory only. There are different kinds of strawberries just as there are different peas and cabbages, and one strawberry plant may vary from other strawberry plants you have seen.

**Root stocks.**

Bright children will not allow themselves to be misled; they will pronounce a strawberry plant to be a perennial, because they see it has a thick root, and they remember that other plants with thick roots—or "root stocks," as the gardeners say—persist from year to year. Now who remembers what it is that enables a plant to begin life over again, as it were, every year? How did gardeners induce cabbages and carrots to give up their annual habits? By starting them so late in the year—you will say—that they had no time to flower before the winter and they laid up stores of food in their roots instead, in order to finish their task in the year following. Well, the strawberry stores its food in this underground part—so far you are right enough. But this is stem, not root; true it gives off fibrous roots beneath, but above it generates leaves and buds. It is, in fact, an underground stem. How does the strawberry's storehouse differ from the tulips?

**Strawberry foliage.**

Let us now pass on to the leaves. First we must find out, however, how much of the foliage constitutes a single leaf. Is there one to each leaf stalk or are there three? The class knows a test—let it find the bud which every true leaf cradles. It is at the base of a triplet (which therefore constitutes a single leaf) and is flanked by stipules which wrap it over protecting the bud tenderly from damp and the cold rough earth. Do you remember we asked once, "What is the use of stipules—they cradle no buds?" Well, they are like the good people who, having no children of their own, mother

those of every one else instead. *Cf.* the beech stipules which take the place of bud scales.

Some of the upper leaves which clothe the flower stems are very much smaller and simpler than the leaves which spring from near the ground. *Cf.* bean leaves. We can find every gradation from the three lobed (compound) toothed ground leaf to the simple toothless leaf which has evidently foregone its share of nourishment for the sake of the neighbouring blossom. The size and shape of a leaf, then, depends largely on the food supply. Do the ground leaves all spring directly from the underground stem? No, the first leaves put out buds of which the stems never lengthen out very much, and which in turn give rise to more very short stems, and so on. The older stems gradually become woody, the parent leaves wither and roots are put out. Thus the underground stem goes on ever increasing in length and number of branches.

**Propagation by runners.**

Bulbs proved to us that young plants are not always due to seeds, and if the lesson is given to country children they probably know that fresh strawberry plants are not planted annually. How then do the gardeners stock new beds? Nature has taught them a lesson which we may pick up from any spreading colony of wild plants. We find that their ground leaves do not always put out flowering or short and leafy stems, but long bare shoots which "run" far away from the parent plant. We ought to feel puzzled why economical Dame Nature should tolerate these "runners"—we remember how the apricot blossom has to squat close to the branches because it does not absolutely require stalks. But there is an object in view. Look at what happens to the terminal bud. As soon as it has got far enough away from the parent plant to have prospect of room and food for a family of its own, it puts out leaves above and roots beneath, and is fed through the runner until fairly started in life. Then the connecting link rots away, and perhaps the new plant has already started a runner of its own. Now we know how the gardener has learnt to multiply his plants, or rather Nature does it for him—he just cuts the runners when he wishes to start a new bed. The only difference between this method of increase and

that of bulbs is that the bud of a scale leaf puts out leaves without delay or regard for crowding the parent's space.

**Propagation by seed *versus* buds.**

We may learn many more ways in which plants increase their kind: meanwhile, does it not seem much simpler that buds should detach themselves than that seed should be produced? But we must consider that in the case of seeds, the offspring—like the children of Greater Britain—scatter far away from the parent plant, thus testing new conditions which involve developments and adaptations, and perhaps fixing some effects of cross-fertilization. Seedlings are apt to take after the plant which gave them pollen, and if a well-marked variety becomes established, a new species is formed. Thus, though a single species might preserve itself by other means than seed, the young plants would enjoy fewer opportunities for improvement.

**Summary.**—The strawberry is a perennial, thanks to its thickened underground stem. It increases by bud-tipped runners which pass food to the young plant until it is established. This method of increase does not give the species much opportunity for variation.

**Art.**—Charcoal studies (in outline only) of strawberry runners as a guide to ultimate design.

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## 52.—STRAWBERRY FLOWERS AND FRUIT (2).

(*THIRD WEEK IN MAY.*)

**Stipule bearing sepals.**

The strawberry flower wears a double ruff of green leaves, five of which are placed alternately with the white petals, and look like true sepals. We feel, perhaps, a little doubtful about the outer circle of the ruff, never having seen a double set of sepals before. On the other hand, we *have* met with a great many vegetable pretenders—sepals trying to look like

petals, pistils trying to look like stamens, and so forth. Perhaps these five outer leaves are also make-believes. There are *not* always five of them—the class may tell the teacher so—sometimes on the garden plant one leaf seems to have split into a brace, making seven in all. Many more would like to do the same, they betray their inclination by a forked tip or a double mid rib. Severed members grow on each side of the corresponding inner sepal. Perhaps you begin to guess now that they are *stipules* which in most cases have joined together to look like sepals. Those belonging to the plants' ground leaves are joined to the leaf stalk along most of their length; but the children may remember instances, as in the beech, where they form independent blades.

Hitherto we have seen only foliage leaves with stipules. Now we have come across sepals which are trying to imitate the leaves; and furthermore, a sepal has even been known to split up into three lobes. It seems as if no part of a plant can be sure of keeping a particular shape or colour all to itself. On the other hand, where there is no monopoly there can be no selfishness, and we observe considerable interchange of function. A new dress generally means something new to do.


**Family traits.**

Do the sepal leaves pull off singly without tearing? No, they are not quite independent like those of the wallflower and the tulips; they remind us rather of the fruit blossoms, especially when we discover further that five is a prevailing number. (Do not be deceived when an overfed garden plant produces a sixth sportive petal. Observe that it is not accompanied by an extra sepal or stipules; plants obey certain fundamental laws, but do not allow themselves to be tied by rule and custom.) The stamens look as if they grew out of

the sepals, but we know the truth already, thanks to our study of the strawberry's cousins.

**Fruit = a swollen flower stalk.**

Let one of the children describe a ripe strawberry from memory. It is soft and juicy all through, dotted over with little yellow points, and surrounded by a collar of green leaves, viz., sepals with their stipules. Perhaps we shall know some day why they do not wither, as in most flowers, along with the stamens and petals. But what makes the soft juicy part ? There is no stone in the middle of it and no seed case that we ever heard of carries its seeds outside—its heart on its sleeve. Yet if we consult a flower, we are forced to recognize the future strawberry in the central yellow mound studded with green beads. A thread grows out of each bead, and, while the mound swells, the threads shrivel and fall away. Shall I tell you the secret ? The threads are the pistil tips and the beads are tiny single-seeded cases like minute grains of corn ! Perhaps you can guess what it is they lie embedded in if you hear that a tuft of leaves was once found growing on the top of a ripe strawberry. *We eat the swollen tip of the flower stalk*—a cup or tube turned inside out—who would have suspected such a thing !

We may therefore conclude that a single pistil is no necessity. In both apple and pear the pistil stalks were separate, but the five cells united to form a single case. Here every cell forms a separate seed case which does not split, but is buried holding its tiny charge, too small for mortal eye to see. Is it not strange to think that the seed cases on a single ripe strawberry correspond to a whole basketful of cherries ?

**Structure of blackberries and raspberries.**

Now compare the structure of fruit which at first sight looks very similar. If possible let children draw their notion of a blackberry or raspberry on the board. Each little round portion contains a hard seed-like part ; these are the " seeds " we find in our jam. Who can tell what fills the hollow inside a raspberry ? It is the tip of the flower stalk which corresponds to the part that we eat in a strawberry ; we are therefore at our wits' end to tell what the juicy part may be. It is

really composed of a collection of little round fruits, each of which is a separate seed case, a miniature plum, cherry or apricot, and the same thing as a hard strawberry grain.

**Summary.**—The strawberry is a relation of the fruit trees that we have already studied, as is shown by the numbers and position of the flower circles. Sepals, petals and stamens grow on a distinct rim, but the tip of the flower stalk is a mound instead of a hollow, and swells into the edible part of the strawberry, with the seed cases embedded in its surface. They are dry one-seeded grains which do not split.

The sepals persist with the pair of stipules—often joined together—which each has at its base. A blackberry or raspberry is a collection of small fruits resembling plums, cherries or apricots in structure.

**Art.**—Brush studies of flower and leaf.

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## 53.—STRAWBERRY FREAKS (3).

(*FOURTH WEEK IN MAY.*)

**Odd stipules.**

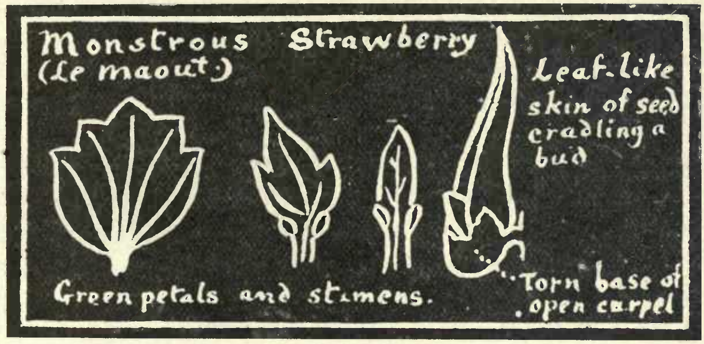
We have seen how liable plants are to alteration according to circumstances. I have now a very strange tale to tell about a strawberry in which extraordinary variations have become established, and which is worthy of a place in Barnum's Show. To begin with, the leaves of the outer ruff are decidedly forked, making no attempt to hide their real nature by a thorough seam. This strawberry blossom is such an extravagant character, that it does not even care whether people know it to be a make-believe or not.

You will be startled to hear what it does next.

**Odd petals.**

Do you remember how melon petals are veined or hairy like leaves ? And we know that in all very young buds the petals are green, colour being acquired with age. Petals, then, do not seem in every way utterly different to leaves ; the

very fact that we call them "flower leaves" shows that they impress us with a sense of kinship. Now in this particular kind of strawberry the petals are all vigorous *green leaves,* with strongly marked veins and hairy margins. In studying strawberry foliage we noticed how the shape becomes simpler the nearer the leaves approach the flower. The green petals




resemble these simplified leaves, and merely show five very shallow lobes. Their position alone tells us that they are part of the flower.

**Odd stamens.**

In the double tulip we found stamens which were nearly petals, and if, furthermore, petals are able to become leaves, we shall be less surprised to hear that stamens can do the same. The twenty stamens of an ordinary strawberry flower form a single circle; here are four circles, one inside the other, each composed of five green leaves, and, unlike the petal leaves, all are stalked. Sometimes there is but a narrow green blade, trimmed at its base with worthless yellow lumps, reminding us of pollen bag relics in double flowers. Occasionally these yellow lumps may be borne at the base of a three-lobed leaf, or perhaps they are missing altogether.

**Odd pistils.**

We have already seen petals instead of a pistil in double flowers, and we have met with plum blossom in which the pistils became very like stamens; so we are not unprepared to hear that in this queer strawberry flower they have caught the general infection and turned to foliage. We know that

the number of branches or tips to a pistil corresponds to the number of divisions in the seed-case. Now if an eccentric pistil splits, it will probably do so along the lines of these divisions. In this case the strawberry seed-case is single celled, so each has become a single leaf, and these leaves grow in spiral lines over the swollen tip of the flower stalk. And what has become of the seeds? Why, each one of them may be found cradled in the metamorphosed cases—a bud of tiny foliage! Perhaps we shall find out some day that seeds do not differ so very much from buds after all.

**Degeneration (unnatural flowers descend from natural blossom).**

Why do we call this oddity a flower, when it can no more fulfil the purposes of blossoming than the double posies of our gardens? Like them, it is *unnatural*, and we do not know what caused the first changes in the natural flower; but these *could* only have been established by propagation through human agency. A plant which can no longer produce seed is bound to die out if left alone. The important point is this—not only that sepals and petals can turn into green leaves, but that stamens and pistil, which in no way remind us of foliage, can do so likewise. Perhaps after all they are more closely related to leaves than has appeared to us. Our fancy pigeons are descended from the stock-dove, and if let loose and allowed to run wild they would soon, in a few generations, be just like ordinary tame pigeons cr their still earlier wild ancestors—but still they would remain pigeons of some sort—they would not become rooks or hawks.

**Interchangeable forms and functions.**

Even so foliage leaves and the members of a flower must be different forms of the same thing; they are alike in nature, otherwise they could not change into one another any more than pigeons could change into rooks. We have seen every stage between little brown scales and green foliage leaves, and every stage between the pistil and the foliage leaf through pistil and stamen forms. Whenever a flower portion has departed from Nature's object it has to run to leaf, and consequently it is supposed that they have been developed out of leaves in the course of ages—that all the circles of a

flower originated in spirals of slightly varied foliage and developed to the plant's profit in the struggle for life and posterity. Successful plants inherited peculiar qualities until these qualities which benefited the plant became fixed. But all this cannot be said for certain. Some botanists find reason for an opposite theory—that leaves were developed out of flower parts. Not only are leaves and flowers of related origin, but stems, roots, and every portion of the plant. Possibly stems may have been the ancestors of leaves Some day a plant may be discovered in some strange plight which will let the whole secret out.

What we have to bear in mind is the wonderful way the plant adapts itself according to needs and altered surroundings. It can alter one organ to suit the function usually required of another; this is thanks to the close kinship of all the parts, in spite of their great apparent differences. Unity is the underlying force.

A flower is composed of members who have each a particular work to do; but each dependent on his neighbour's performance of duty, and willing, if necessary, to help with a portion of his neighbour's work.

**Summary.**—Plant members have kindred origin, as is proved by their interchange of form and function. The alpine strawberry flower, as a monstrosity, seems to prove that the green leaf is a parent shape. On the other hand, leaves may have been developed from stems or from the floral members.

**Art.**—Border design with the brush. To be based on the preceding studies.

# 54.—ROSE BRIARS AND SUCKERS (1).

(The Briar is the Wild Rose.)

(*FIRST WEEK IN JUNE.*)

**Propagation by suckers.**

Whoever has cleaned a hedge knows that it is hard work to get rid of briar "suckers." For why? These leafy shoots crop up from running underground stems season after season; and wherever they can hide themselves from the pruner's hands, their root-stores enable them to grow wood and to put out branches, thus forming bushes. The parent, like the old strawberry plant, may be yards away, and when the young bush becomes self-supporting the connecting link rots. Now what is the difference between the rose sucker and the strawberry runner? In the one case there is an underground, in the other an above-ground connection. The children ought to pull up some briar suckers and distinguish (1) the underground stems, (2) the root store-houses, (3) the feeding roots.

**Thorns are modified hairs or branches.**

Perhaps if the children remember how the melon plant became prickly in its old age, they may notice the gradual hardening and thickening of rose hairs into protective thorns. (The climbing rose holds on by these weapons, so that they serve a double purpose.) The class must not conclude that all thorns are developed from hairs. Nature has many ways of achieving the same end, and acts according to circumstance. For instance, in the case of a wild pear growing in poor soil, she saves the plant's strength by arresting the growth of some of the branches. They remain behind the rest, leafless thorns; but the last shall be first, and they protect their prosperous brothers from harm.

**Leaves compound and sometimes the sepals also.**

The class must next distinguish between the toothed stipules and the leaves; and notice the more or less kindred shapes of the sepals. Are these all equally developed in the

same flower ? The innermost are simplified, as are foliage leaves, the closer they approach the blossom. This suggests the thought that some of the sepals may be nearer the central parts of the flower than others. On investigation it will be found that there are two outermost, two innermost, and one which overlaps an inner, and is itself overlapped by an outer sepal. The petals follow suit, thanks, we are sure, to no accident; we expect them to grow in the same ordered way as the leaves from which they are probably developed, namely, in a spiral. (Lesson 3.) If we return to a stick and twine we shall be reminded that two turns of the string completes a spiral of five knots (representing the buds). Now imagine the intervening spaces much shortened, as between the leaves which compose a bud, and behold! the arrangement is that of our rose sepals and petals. The modified leaves of a flower have to grow close together in order to fulfil their purpose. We can now understand why the innermost sepals are the most simplified: they are the youngest, and approach the centre of the blossom.

The floral circles, then, are really formed by a very close spiral. It first occurred to a German naturalist that they might be composed of modified leaves when he found a rose in which there was an interval of stem between each more or less leafy portion of the flower.

You can understand now that when true leaves grow opposite to each other, or in a circle round the stem, it is because there has been no growth in between. Compare how the seed-cases of the strawberry are arrayed in spiral lines on the central mound.

**Summary.**—The rose is a perennial which may be increased by suckers. The thorns are protective, and also assist some kinds of roses to climb. The compound sepals clearly betray a leafy origin; the innermost are the most simplified—an analogy to foliage which is explained by the fact that floral circles are really arranged spirally, like the leaves. As in a leaf-bud, the outermost floral leaves are the oldest and overlap the inner and younger.

**Art.**—Outline a very simple spray of wild rose in charcoal, as a guide to ultimate design.

# 55.—ROSE HIPS AND HAWS (2).

(*SECOND WEEK IN JUNE.*)

**The Rose Family.**

No matter what rose we study, we find the sepals and petals arranged in circles of five, and perhaps we should find the stamens number a multiple of five, could we count them. All grow on a rim formed by the flower stalk, which latter is hollowed instead of humped (*cf.* the strawberry). Now number and position are important, tribal and family features—such lesser matters such as size, presence or absence of hairs, thorns, etc., merely create varieties. Let the children collect as many kinds of rose as they can find, and note the trifles which constitute a difference between each kind—all are roses nevertheless, just as we are all men. All may claim descent from Adam yet all are not equally closely related. Imagine a lot of little Joneses, some brothers, some first cousins, some second cousins, etc., but all belonging to the same tribe or class of Jones, because they have the same great-grandfather. In the same way the apple may not be so closely related to the plum as it is to the pear, yet all these belong to a single family of plants which is named after some of its members, the roses. To which section of the family are the roses themselves most nearly related ? Let us examine a flower before attempting an answer.

**Hips and Haws.**

We shall find petals and stamens connected by a yellow ring on the edge of the cup, and they surround a bunch of things which may perhaps be pistil tips. Yes indeed ! They poke their

heads through the central, partially-covered cup or hollow, which, if you look within, you will find full of very hairy seed cases, each containing a single seed. They grow from the sides as well as on the bottom of the cup. Does it occur to any of you that this rose hip is like a strawberry (or a glove finger !) turned inside out ? Both strawberry and hip are not eaten for the sake of the seed vessels, but for the sake of the swollen stalk which holds them. (Which of the children have made or tasted hip jam ?) The seed vessels in both plants are dry, one-seeded, non-splitting, whereas we remember that in other members of the tribe the seed cavities formed part of a single case. Those of the apple and peach were divided into five ; those of apricot, plum and cherry into two. So we may conclude that the strawberry and rose families are very nearly related.

How long will it be before the hips are ripe ? What will they look like then ? Do not confuse them with the hairy haws which are swellings (like oak apples), caused by the prick of an insect when it lays its eggs. A haw cut open will be found swarming with animal life.

Perhaps one of the scholars can draw a ripe hip on the blackboard ? Do all wear a crown of faded sepals above their crimson (or jet black) robe ? Their costume lures the birds who probably have to carry away the hairy pistils, even if they do not like to swallow them. And thus the roses get sown far and wide. The class should recapitulate all it has learnt about various fruits. What is the part we eat in the raspberry ? What corresponds to the eatable part of a strawberry ? What part of a rose hip corresponds to the juicy part of an apricot, etc.

**Summary.**—The rose gives its name to the tribe which includes families of apricot, plum, cherry, pear, and strawberry. In all the tip of the flower stalk develops into a rim from which grow sepals, petals, and stamens. Five is the typical number. None of the seed-cases split ; and the rose hip, like the strawberry, is composed of the swollen stalk bearing separate single-seeded pistils. But in the rose these grow within a hollow instead of outside a mound.

**Art.**—Pencil and brushwood studies of various portions of the wild flower. Study Haités' pencil-work on flower and hip.

# 56.—ROSE MONSTROSITIES (3).

(*THIRD WEEK IN JUNE.*)

**Value of monstrosities.**

What is meant by a "monstrosity," or a "monstrous" flower? We mean an unnatural monster, which has grown in quite a different way to what its kind does in ordinary conditions. Directly man, for instance, interferes, the flower cannot do Nature's business properly—if at all. Mention a very common garden monstrosity. It is a double flower, in which many of the parts have evidently turned to petals. What does it teach us? The very close relationship of the different parts of a flower, and sometimes—as in the strawberry monstrosity—of the parts with foliage. One part of a plant could not turn into another if it were not of similar nature, and monstrosities are interesting because they reveal relationships.

**Variation encourages variation.**

Most kitchen garden plants possess monstrous flowers, leaves, buds, stems, or roots, and we studied the causes of their variation before. It is easy to perceive that once one part of a flower plays tricks, the other parts, like bad children, will be likely to follow suit. For they depend very much on one another's help in perfecting seed, and if one part goes wrong the reason probably is that the rest cannot get on at all; and so they save themselves the trouble of growing in their usual perfect way. Thus, if stamens have turned into petals, the pistils either contain no seed or do not trouble to roll up into seed cases—they remain open leaves, as in our monstrous strawberry plant. They know that there is no pollen to fertilize the seeds.

Perhaps we discovered last week that there are a great many different kinds of wild rose, though some may resemble each other very much, and all are probably descendants of a common ancestor. So we see that it is not only through man's influence (as with cabbages) that variations occur and become established.

### The Double Rose.

It gives almost as much pain to think of a double rose as monstrous, as it would to dub beauty a beast. Yet so it is. Let one of the class try to explain the result of man's interference. Double roses possess many more petals than their wild cousins, but fewer stamens. We put two and two together, and conclude that stamens have turned into petals. But the great number of the latter may still be unaccounted for. The fact is, flowers can not only change their parts, but add to them; and highly-fed roses are very likely to perform this feat. It is interesting to note the intermediate forms, half stamen, half petal; and we wonder whether it is the stalk of the stamen or the pollen bag which possesses this strange power of putting on a leafy disguise. Let us look. Some of the more shapely petals retain a stamen stalk, and many less advanced—or depraved, shall we say?—retain half a pollen bag also. It seems as if the stalk, like an ordinary leaf stalk, widens into a blade, or else rolls up a closed membrane to hold pollen. Perfect petals and stamens are quite unlike each other, yet we find every intermediate stage between the two.

### Kinship of sepals and petals with foliage.

Perhaps some of the children may one day come across a very rare and odd monstrosity. Like many another, it begins life with good intentions; true, the sepals are like true leaves, but the petals and stamens are quite good and commonplace. Then the stem suddenly makes up its mind not to leave off after the seed-cases are formed. It produces another flower bud (or else foliage) in the midst of the stamens, and then goes shooting aloft with the pistils, as open leaves, arranged in a spiral along it (*cf.* what we learnt in the last lesson about the spiral growth of floral leaves).

Other monstrosities grow buds at the feet of petals, stamens, and even of unfolded pistils, thus betraying the leafy nature of all these parts. For we know that it is an unmistakable symptom of leafhood to cradle a bud.

**Summary.**—Monstrosities are the result of reversion, or of adoption of a kindred form. Double roses show intermediate stages between stamens and petals, and more rarely the sepals turn to foliage. Sometimes the central stem does not cease

with the flower, but continues to produce other buds or leaves with spirally-arranged pistil leaves beyond or between. Also petals, stamens, and even pistils produce buds in their axils. If one member changes, the rest are liable to do the same owing to interdependence.

**Art.**—Brush design based on previous studies.

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## 57.—COLUMBINE (1).

(*FOURTH WEEK IN JUNE.*)

[The dark purple perennial finds a place in our gardens along with more showy cultivated varieties. The latter are not true perennials, but rather biennials, a difference which may be traceable to lesser roots. Let the children investigate this matter for themselves, and state what other plants, which they have studied, possess root *versus* stem storehouses. However, there is no hard-and-fast line to be drawn between biennials and perennials, for some so-called biennials will live through more than one winter. Either kind is suitable for these lessons.]

**Foliage gradations.**

How much blade goes to a single leaf? From the columbine's foundations spring stalks, which divide into three lesser stalks, each of which bear three separate deeply-lobed leaf-like parts. Do we see one, three, or nine leaves? The class knows by this time what tests to apply. Notice the rapid simplification of these compound leaves as they approach the terminal flowers. It is easy to understand the near relationship of seemingly different parts when circumstances produce such variation in the foliage of a single plant.

**Enlarged leaf bases.**

The class should notice how the leaf stalk cherishes its parent stem and child bud with outspread strands. Similarly these separate above to support the leaf blade.

**Flat and hollow floral leaves.**

The columbine was named after the dove by god-parents, who likened it to five fluttering long-tailed doves looking down

into a nest. It has five sepals, which have put on this fanciful disguise, and five petals. Pluck one of the latter off by itself, and some of you may be reminded of a hollow curly ram's horn—others of a dunce's cap. In the tip is a hard, round knob containing . . . what? a prick will discover honey.


But for our recent studies we could never suppose these hollow petals to be akin to stamens, sepals, or foliage.

**The stamens.**

I do not think any of the children will be clever enough to count all the stamens except by looking through a magnifying glass at the scars they leave behind when they fall off. There are fifty of these, arranged in circles of ten each. We shall learn something about fertilization by noticing whether the pollen is let fall inwards (towards the pistil) as is the case with the rose family and many more, or whether it falls outwards on the petals. Yes, the columbine seems to be more intent on cross-fertilization than the flowers which we have just been studying, and prefers to dust the bees when they alight on the petals, rather than its own pistils.

The stamens are of various lengths, so they do not all shed pollen at the same level, but may dust a bee as he moves from place to place.

**Respective origin of hollow and flat petals.**

Columbines may become double in the usual way by producing extra plain petals, or else several hollow leaves, growing most funnily one inside another. Just as if a lot of dunces sat in a circle hanging their heads, and each with several caps on, one over another.

The greater the number of these extra petals, the fewer stamens we shall find. Now, what is most likely—that

stamens originate from petals, or petals from stamens? Stamens are absolutely necessary to a flower and petals are not; therefore it is reasonable to suppose that the former are the earliest developed and that signal flags develope according to later arising need.

But the flat and hollow petals are so unlike, surely they originate from different parts of a member, if not from different members? Let us examine intermediate forms. We shall find that the hollow petals are large lipped, and these are sometimes replaced by stalks exactly like those of stamens, which are capped by hollow bodies of all sizes and dwindling in some cases almost to the aspect of a pollen-bag. The honey in hollow petals seems to represent the pollen in the stamens.

The flat petals, on the other hand, may be found with small pollen bags *on their tips*, which proves that they are really flattened out stamen stalks.

A whole lesson might be spent in studying the revelations afforded by double flowers.

**Origin of the scales.**

What is the meaning of the double collar round the pistil's neck of silvery, mid-ribbed, crinkly-edged scales? Their position, and the occasional presence of pollen bags on their tips, point to an origin from stamens rather than from pistils. Poor dwarfed, cramped things! They were not allowed enough room by their fifty brethren to form pollen bags, and their stalks seem to have been pressed into flat blades, reminding us of the petals we have just been studying.

**Seed case superior.**

What is the great distinction which should first strike us between the columbine and members of the rose family? It is the position of the floral circles. The apple's seed case, for instance, was situated beneath the flower—it was "inferior." In wallflowers, tulips, and columbines the floral circles spring from *around* the seed case, which is quite unconnected with them and, as the latest product of the stem, is therefore slightly "superior." In the rose family, sepals, petals, and stamens come off the rim of a sort of tube or shallow cup formed by the tip of the flower stalk, whereas the columbine

stem rounds to a platform. True, the plum blossom's seed case is unconnected with the outer circles, but it is *below* them, thanks to this cup rim. During the next few lessons we may discover that the columbine has some very unexpected relationships—just as the roses have—and perhaps some day we may be inclined to say of the plants' families what is often said of men—that "all the world is akin."

**Summary.**—The columbine is perennial, but usually becomes biennial under cultivation. Possible variations in foliage and petals well illustrated. Floral circles composed of five and its multiples. The stamens shed pollen outwards. Their innermost circle is represented by scales. The seed case is superior.

**Art.**—Charcoal outlines and brushwork studies of flower and foliage, as guide to design.

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## 58.—COLUMBINE (2).

*(FIRST WEEK IN JULY.)*

### Easy method of self-fertilization.

Let the class consider how it may be possible for a drooping flower to fertilize itself, and then it will be the more readily noticeable that elderly pistils project a little beyond the stamens, thus making self-fertilization easy, and providing, as often happens, a second string to the plant's bow.

### The task of the long-tongued bee.

If the columbine were content with self-fertilization alone it would not trouble to produce honey. On the other hand, the honey is tucked away in a very odd place; how ever are insects to penetrate the tip of the curled petal? Notice what kind of bees visit the flower; only those with very long tongues can get up there; they ram their head right away in. The poor things have to hang back downwards—a giddy feat we should think!—but they steady themselves by clinging with

forelegs to the petal's lip, and by clasping stamens and pistils with middle and hind legs. Now, in *young* flowers the stamens are lower than the pistils, so the bees get well dusted; but in old blossoms, as before said, the pistils have grown out beyond the stamen barrier, a circumstance which not only facilitates self-fertilization, but also forms a trap for pollen from younger flowers.

**Short-tongued robbers.**

Hive bees and some others have such short tongues that they cannot reach the honey in such a way as to catch the pollen. But they do not care whether they earn their wages or not; they cheat the flower by biting holes through the petal tips. Thus they rob the honey and injure the plant instead of serving it.

**Five single-leafed pistils.**

We can tell without looking that the five pistils are single-celled. For why? Each is tipped by a single spike. Run the finger nail between both clearly-marked edges of a pistil, and flatten it out. We see how leaf-shaped it is, and, on the other hand, we can make one of the simpler foliage leaves very pistil-shaped by curling it up, edge to edge. We have learnt that all pistils are composed of leaves, but some betray their origin far more clearly than others. Columbine monstrosities have actually been known in which the pistils have not closed, and the hopeless seeds have followed suit; they have formed a row of tiny leaves growing along the edges of the open seed vessel (*Cf.* the seed buds of the monstrous strawberry).

**Escape of the seeds.**

How do well-behaved columbine seeds escape from their tight little prison? Perhaps the children may arrive at an answer by comparing previously-studied seed-vessels. The fruit is evidently not attractive to birds like the cherry, neither is each seed lodged in a tightly-fitting inseparable case like grains of corn. Perhaps the brittle membrane calls tulip and wallflower seed-vessels to mind, and we know they split along their seams to let the seeds out. Perhaps the columbine behaves similarly, and we can

verify our surmise by watching a plant on some hot dry day. See, then, if the cases split suddenly with a jerk; for supposing they did so, it would be of great benefit to the plant. For why? The seeds, instead of crowding each other at the feet of the parent, would be scattered far and wide, like stones slung from a catapult.

**Simple *versus* compound pistils.**

A columbine pistil (like a leaf) is called "simple" if it is composed of a single blade. Where several leaves join together to form a pistil, it is called "compound." The tulip, you remember, does this. If the five leaves of the columbine were joined to each other along their edges, they, also, would form a compound pistil. (This can be proved by paper models.) The simple pistil is very honest about its foliage origin, but the compound pistil tries to hide it. Perhaps it is because simple pistils come of very old families; it is supposed that long ago there were no compound forms, only simple evenly-shaped leaves, sepals, petals, stamens, and pistils. The wild French columbines (with flat petals instead of hollow ones) may have had similar ancestors long before Adam and Eve.

Compare the other flowers which have been studied. Complications arise because they are of some service to the flower. The melon's forerunners probably had free and distinct parts of equal number. Irregularities in form and number have arisen from the junction or the loss of formerly distinct parts.

**Summary.**—Columbine pistils are at first covered by the stamens, and afterwards project beyond them. Bees suck the honey through the petal tube, and promote cross-fertilization by clinging to stamens and pistil (short-tongued bees cheat). The pistil splits to scatter its numerous seeds, and is composed of a single leaf. The columbine is a primitive type, showing symmetry in both number and position of parts.

**Art.**—Design based on previous studies.

# 59.—THE CROWFOOTS (1).

(*SECOND WEEK IN JULY.*)

**Derivation of Buttercup and Crowfoot.**

It is not difficult to guess why the Buttercup should be so-called. It has a great many first cousins—most of them very like itself. Perhaps the children can name a few? The "spear-warts" (so-called from their narrow leaves) are found in bogs; so also is the marsh marigold. The globe flower of northern England is often found in our gardens. The water ranunculus is a pretty white flower, common in ditches. It is remarkable for producing two kinds of leaves—one kind very finely cut floats like seaweed in the water currents, while broad-lobed foliage, something like that of the columbine, squats on the mud above. Now that we have come to the subject of leaves, perhaps some child may suggest why all these plants are called "crow-foots"? (*Cf.* the names Birds-foot Trefoil, Larkspur, and Cranesbill, if the children are already familiar with the aspect of the plants so called.)

**Gradations of foliage form.**

What did we notice concerning the shapes of both strawberry and columbine foliage? Did we not find every stage between simple, deeply-cut, and compound leaves? Now, those of the crowfoots divide into three often long-legged parts. Each of these splits into three more, and sometimes the central part has a distinct stalk. Again, these secondary divisions tend to treble themselves, and these last parts of all are often notched in their turn. But the very complex leaves gradually become more simple the higher they grow up the stem, until at last each leaf consists of only three narrow un-notched blades. These most resemble crow's feet, of which the lower secondary divisions subdivide once with little notching besides, so that five toes are clearly marked. The name suits some members of the family better than others, according as the divisions are spreading, deeply cut, and claw-like. Butter-cup leaves remind one slightly of the far more rounded Columbine foliage.

**Crowfoot Roots.**

Who knows what the root of the common buttercup is like? It is a kind of bulb, not composed, however, of scale-leaves (like those you have studied before), but of solid, thickened stem. Is it, therefore, annual or perennial? In other words, if we picked all the heads off buttercup weeds, would this prevent them from coming up another year?

A crocus bulb forms the connecting link between the scaley tulip and the scaleless buttercup bulb—its distinctive feature being the formation of young bulbs on the top of the old. Who remembers how tulip and onion bulbs increase? Perhaps by pulling up buttercups we may find how they manage their nurseries. We shall discover at the same time that some of the crowfoots are annuals, with their fibrous roots. Others are perennials, thanks to a far-stretching underground stem.

**Runners of Creeping Crowfoot.**

Which child knows where to find the "creeping crowfoot," and will undertake to show it to the others? The name leads us to expect that, like the strawberry, it throws out "runners," which sprawl over the ground and produce separate plants in time. Let the children compare the origin of crowfoot and strawberry runners. The former spring from buds some way up the stems—the latter from buds on very short shoots.

**Survival of the Fittest.**

The crowfoot family is trying experiments. They must all be descendants of one ancestor, but different circumstances have caused them to vary in different ways in order that they may hold their own and multiply. Some, we see, are annuals, some perennials—some live in water, some in bogs, some in dry fields. The kind which has suited itself best is the most successful, and perhaps some day it may oust the other kinds which share its situation. The children should try to distinguish the different sorts and their preferences, and perhaps in the next lesson they may be able to tell the teacher which is most thriving, and why.

**Recapitulation of Methods of Comparison.**

What are the points we think about when we distinguish one flower from another? Our thoughts probably first fly to the colour—then to the size and general shape of the blossom. Perhaps if we found these distinctions insufficient we might count the number of parts which compose the floral circles and consider their relative position. Then we might count the pistil cells and seeds. In short, we should examine the colour, size, shape, number, and position of sepals, petals, stamens, and fruit. But ought all these points to receive equal attention? For instance, is there any reason why we should consider the pistils rather than the petals, or the situation of the petals rather than their colour? Yes! For we have discovered before and shall do so again, that even similar flowers are not the same. Certain features (like colour and size) vary greatly, whereas the position of the flower circles and the character of the seed-case remains constant. These latter points, therefore, are most valuable in comparing flowers.

Next time we shall examine the Buttercup, first for its own sake, and then, in order to determine whether we have already studied any of its more distant cousins. (A number of crowfoot specimens should be collected by the children for this purpose.)

**Summary.**—The Buttercup and its numerous first cousins of water, marsh, and land growth, belong to the crowfoot family—so called from deeply-cut claw-like leaves. The buttercup proper is perennial, having an underground stem thickened to a bulb. Other crowfoots have fibrous roots only, or creeping underground stems. The creeping crowfoot throws out strawberry-like runners. Position and number are important points of floral comparison.

**Art.**—Charcoal outline studies of buttercups; leaf and flower as a guide to design. (*See page* 161.)

# 60.—BUTTERCUP FLOWERS (2).

(*THIRD WEEK IN JULY.*)

We shall begin our examination of buttercups with the less important outer circles because we must pull them off in any case in order to examine the pistils.

**True buttercups distinguished by reflexed sepals.**

To begin with, what grand hairy blankets these sepals are! What becomes of them when the opening flower throws them off? They either end by falling right away, or they cling on to the base of the petals. On comparing the roots and leaves of the plants which behave thus differently it will be discovered that only two sorts cast off their blankets. One of them is the true buttercup, and this trifling point makes it easy to distinguish from its first cousins. We are cleverer than the bees, for they may be watched flitting from one crow-foot to another, whereas it is quite against their usual rule to visit more than one kind of flower at a time. It would be interesting to know if this want of discrimination results in any curious crossings.

(It is a very debated question how far the pollen of one kind of plant is able to fertilize the seeds of another kind. Darwin supposed foreign pollen to be injurious if not ineffectual. But the case of very nearly related plants may be different. Further discoveries about origins might greatly affect the value of field and garden crops.)

**Position of honey.**

Where do the bees find the honey? In a little pocket at the base of each petal. Imagine it ever so many times bigger till it came to resemble the hollow columbine leaves, likewise attached by their lips to the stalk tip.

**Cross and self fertilization.**

Who can remember which way the columbine pollen bags open? Downwards, and those of the buttercup do the same,

eager to scatter a shower of dust on intruders. The inner stamens open last, another point which reminds us of the columbine.

If insect visits fail, is self fertilization possible? Yes, for the inner stamens are so close to the pistils that a crawling insect would certainly jostle them. Insects sometimes do the opposite of what the flower likes best, you see!

**Buttercup sleep.**

Another circumstance must often lead to the stamens getting pressed against the pistils. Have the children ever noticed how the fields lose their yellow carpets in the evening? The flowers have not all dropped (how long do they live by the way?) they are just nodding with half closed petals to keep the dew from pollen and honey.

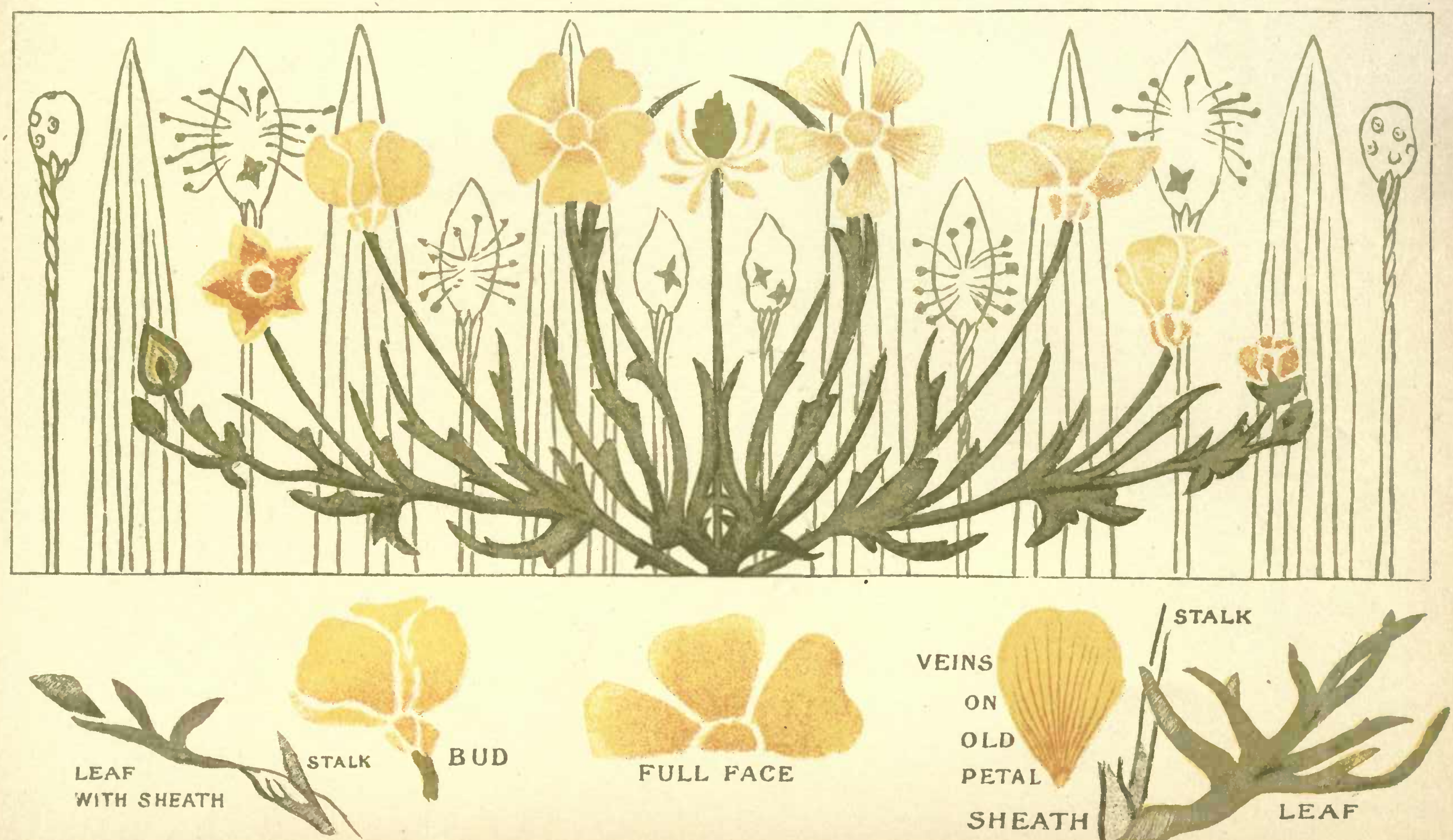
Linnæus, the Swede who classified all known plants, kept a time table which he called his flower clock; though he was such a great man he loved, for their own sake, such trifles as the hours when blossoms get up and go to bed, and the number of days they last. He did not know (what perhaps you all have guessed) that these times and seasons depend on the frequency and kind of visitor expected, in short on the method of fertilization practised. (The snowdrop for instance has a longer life than the buttercup because its winter days are short and contain less chance of visitors.) He did not need the inducement which each of us have now to keep a flower clock for ourselves.

**Flower number is 5.**

Five sepals and five petals alternate with each other. The stamens are too numerous to count, but we may surmise from experience that they are some multiple of five. Some luxuriant flowers have six or even more petals, a tendency to double because of unusual food supply, etc. Let the children instance double garden crowfoots.

**Superior seed vessels.**

The seed cases are "superior" for it is evidently the pistils that are dotted spirally all over the little green hillock in the centre of the flower. (Remember that *all* floral circles really constitute close spirals.) Each pistil looks like a little


LEAF
WITH SHEATH
STALK
BUD
FULL FACE
VEINS
ON
OLD
PETAL
SHEATH
STALK
LEAF

green cap pointed towards us, with its peak sometimes yellow with pollen. The broad part is sufficiently transparent when held up to the light to disclose the presence of only a single seed. It is within a "simple" case therefore, which does not split but buries itself with the seed (*cf* grain, etc.).

**Loss of twin seed.**

When we opened the columbine's seed case, what did we find growing each side? A row of seeds on either edge of the closed leaf. Now for a puzzling question! Which edge does the single buttercup seed choose to grow upon? The fact is each leaf margin *ought* to correspond by growing one or more seeds. Remember how the apricot has two to start with though one nearly always dies. Well, we know that plants take a long time to change and the apricot is only now doing so; in course of time it will follow the buttercup's example and learn not to produce the fore-doomed seed at all. If our eyes are keen enough we may examine every baby buttercup on acres of land and never find a trace of the second seed. "Why should we suppose it was ever there?" some inquisitive child may ask. "Surely all flowers need not follow the same rule?" But a microscope testifies to the grand fact that Nature, in the midst of diversity, is faithful to a few simple laws. At a stage too early for our naked eye to see, there *is* material for the twin seed!

**Struggle for existence among pistils.**

Look at the fruit of a buttercup after the petals have fallen; are all the seed cases of the same bulk? Evidently only a few have room to ripen and the rest have to make room by dying. So the buttercup (like the apricot) is in the act of making a change. In time the plant will only produce as many seed cases as it can afford to mature (*cf* the struggle for existence among young apples, etc.).

**Independence of parts.**

We have now travelled all through the buttercup flower, and have seen as much to interest us as "Alice in Wonderland." Compare other blossoms we have studied. The seed vessel of the crossworts we found to be "superior" but not simple, and the flower circles differ numerically (except in so far as

all contain two, or multiples of two). Those of the melon are united and the fruit is inferior. The tulip is an inside grower. The rose family has an inferior seed vessel. The strawberry fruit is only an apparent exception, for the rim on which the outer circles grow is above the base of the central mound. There remains the columbine with its faithfulness to the figure five, its disunited parts, and its collection of simple seed cases placed superiorly. It is in fact related to the buttercup, and perhaps its starry blossoms in the French fields may call to mind the primitive type of the crowfoots more readily than our spurred columbine at home.

**Summary.**—The buttercup resembles the columbine in numerical completeness, inadhesiveness, number of stamens, with pollen bags opening outwards, in the secretion of honey, and in the position of the pistils. Both belong to the same family.

The buttercup may be distinguished from near crowfoot relations by its early falling sepals. Cross and self fertilization are both possible. The seed cases are single celled and do not split. They grow spirally in great numbers, but all do not reach maturity. The buttercup is one of those flowers which protects itself from cold and wet, and promotes self fertilization by half closing and drooping at night.

**Art.**—Brush studies of buttercups, leaf and flowers.

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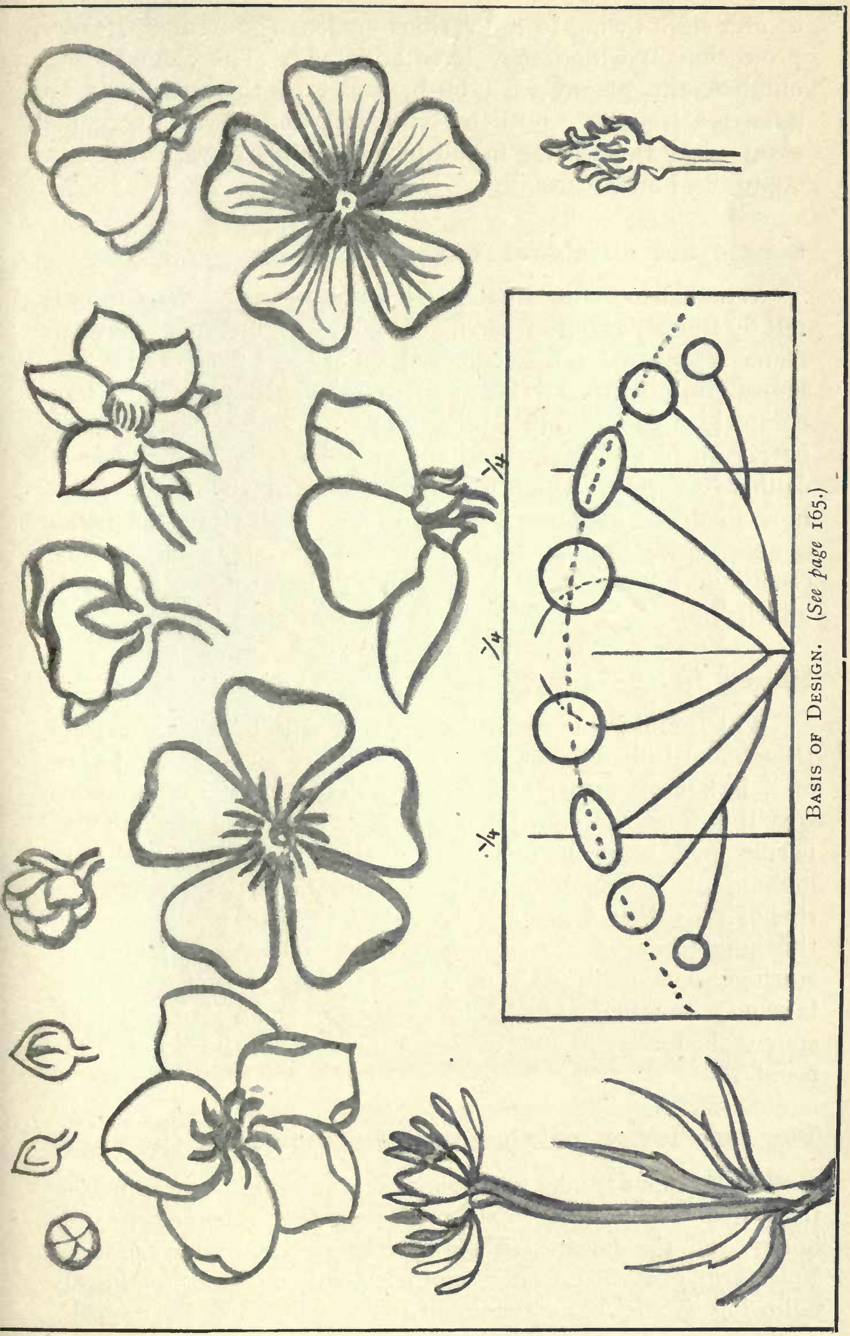
## 61.—LARKSPUR.

(*FOURTH WEEK IN JULY.*)

**Ranunculus family.**

Larkspur, monkshood, pæony and clematis, are all related to the columbines and crowfoots,—that is to say they belong to the Ranunculus family. The children should be questioned as to what they know about these plants and encouraged to bring specimens (in seed if not in flower) to class, and they should study which characteristics evidence relationship. How utterly different members of the same family may appear



BASIS OF DESIGN. (*See page* 165.)

at first sight owing to the various modes of growth (instead of professions !) which they have adopted ! The clematis is a climber, the pæony is a bush, some of the crowfoots are annuals, larkspurs furnish both tall and dwarf perennial plants, and these being in full bloom at present we propose to study the flower carefully.

**Sepals act as signal flags.**

Which leaves are sepals, and which petals ? We can only tell by the situation of each. What other instances have we come across of brightly coloured sepals ? Those of the tulip helped in advertising the plant, but here they seem to have completely adopted this function ; the white petals hardly betray their presence,—perhaps they have some new special calling to perform which we have not heard about yet. Anyhow, in drooping flowers the sepals naturally hide the petals a good deal; so they either take on the signalling, or else remain very dwarfed in size (as in the harebell) so as not to interfere.

**Honey in the spur.**

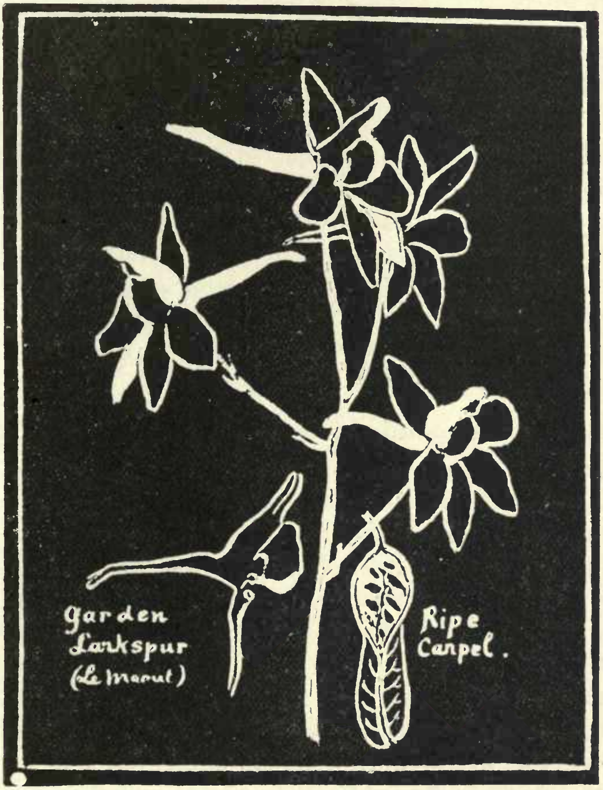
Which child can explain what is meant by a cock's spur ? (Blackboard illustration.) And has the very long hind claw of a lark been noticed ? Now, perhaps, it can be guessed why this flower is called a larkspur. Supposing we had five purple spurs before us instead of one, we might fancy we were looking at a columbine. The columbine had honey in the tips of its rather less spur-like petals. What has become of the honey here ? Can the petals be so lazy as to give up storing honey as well as signalling ? Not so, though it may take us some time to find out that two of them form a honey-spur tucked away inside the sepal spur. Bite the tip of it for proof.

**The two lower petals form the mouth of the spur.**

The larkspur thinks that four petals suits its purpose better than five. The upper pair roof over the entrance to the honey, and the lower pair spread themselves out in front as a platform. All fit into one another, neatly co-operating in the following wonderful arrangement.

**Contrivance for dusting bees.**

The stamens are numerous (as in columbines, buttercups, etc.), and they all seem to stoop beneath the platform as though they were afraid of bumping their heads. Let a finger play the bee's part and press down the platform—what springs into view like Jack in the box? Two stamens! yellow with loose pollen which is all ready for the bee's tongue or head as it reaches down the tube after honey. The other stamens are




either unripe or have already cast their pollen in this singular way. But two always ripen together, and as they do so they raise their heads to the gap formed behind the spur by narrowing of the two front petals. So it is that they are ready to meet a bee when its weight presses down the platform. When they have disposed of their pollen, they bend down once more and are replaced by two more ripe stamens.

**Self-fertilization impossible.**

We have learnt now how it is the bee gets dusted, but all this time we have seen nothing of the pistil tips. Where ever are they hidden away? If we examine an old flower we shall find that they have taken the place of the pollen bags at the entrance to the spur. They ripen last of all, remaining bent beneath the stamens till every speck of pollen has been cast. Self-fertilization is thus rendered impossible, the flower relying on bees flitting between young and old blossoms.

**Order of the flowers on the stem secures cross-fertilization.**

Do all the flowers on the spike open at the same time? If so, cross-fertilization would have to depend on the spikes not flowering together. We can see, however, that the lowest flowers are the first to open and are therefore the oldest. If we watch bees visiting the flowers we shall see that they always start at the bottom of the spike, and work their way up from flower to flower. They thus carry the pollen from the young blossoms at the top of one spike to the old flowers at the bottom of the next.

**Fertilization dependent on a single kind of insect.**

While we watch the flowers let us notice, also, whether there is more than one kind of bee at work. It is supposed that only one British bee (the Humble bee) has a tongue which is long enough to reach all the way down the spur. Is it the same insect which fertilizes the columbines? Both flowers show traces of cheating bites inflicted by short-tongued robbers.

The larkspur is the first flower we have studied which is so ambitious as to depend entirely upon the services of bees. It comes of an orderly, primitive old family but it has sacrificed this prestige and adapted itself to quaint experiments in order to be propagated solely in a way which shall most develop the kind, and secure its strong continuance.

Thus far we have only brought our pupils to the borderland of marvels. They may explore further for themselves with the help of Sir John Lubbock's little books ("The Beauties of Nature," etc.), wherein they will read much about devices for securing fertilization.

**Summary.**—The Ranunculus family contains highly differentiated members. The larkspur is an instance of flowers in which self-fertilization is rendered impossible by the pistils ripening after the stamens. The bright sepals act as signals and their spurred member contains the nectar gland. The two lower petals create a platform for Humble bees. The stamens ripen in couples and raise their heads to the mouth of the spur. The bees' head or tongue comes in contact with the pollen directly his weight presses down the platform. In old flowers the pistil tips replace the stamens. The lowest flowers on the spike are the earliest to open and the bee travels from them upwards.

**Art.**—Brush design of buttercups, based on preceding studies.

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## 62.—POPPIES (1).

(*THIRD WEEK IN SEPTEMBER.*)

### Numerous Varieties.

How many poppies can the children describe? They must all be familiar with the scarlet blossoms of the cornfields, though they may not have learnt to distinguish more than one kind. Then there is the thousand-coloured garden race, many of which may be descended from their wild cousin (*Cf.* the descent of cabbages). Also the yellow "Welsh" poppy and lastly, the giant "opium" poppy, which is seldom found wild in England. Its great seed-vessels seem almost wooden-walled, they are so strong and thick. Some of the children may have seen them at bazaars, stuffed as pincushions, but probably few have bruised them while young and green, in order to see the milky juice flow out.

### Opium.

Both stems and seed-vessels are thus pressed out for the sake of . . . . . what manufacture? For the sake of opium, which is just hardened juice, used in Eastern lands for the sake of its very soothing, sleep-giving powers. The people

put it into their drinks, chew it, or smoke it instead of tobacco, and it utterly stupefies those who use it in excess. In olden days English people made a sort of mild soothing medicine by stewing red poppy petals.

**Perennial and annual poppies.**

Are poppies annuals or perennials? Garden poppies are of both kinds, the perennials flowering earliest. Why? Because leaves and flowering shoots are able to sprout all together, food being ready prepared for them; but annuals must get their own food while they grow, and cannot afford to produce flowers so soon. The red corn poppies are annual, but the yellow Welsh cousin is a perennial.

**Character of foliage.**

The stems and leaves of the opium poppy and of its varieties are almost smooth, but most poppies are covered with straight projecting hairs (except in the case of one of the corn weeds where they lie flat against the stem). Notice the fellow-feeling which seems to exist as usual between leaves and sepals,—both are hairy or smooth together. The leaves are arranged singly up the stem.

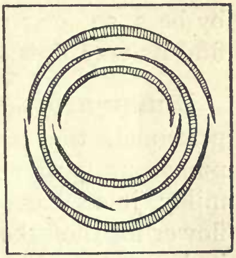
**Bud coverings.**

You would not think that the meek little poppy bud with hanging head, is capable of an act of violence? Yet it presently does a very rude and determined thing, as you may guess if you look at a newly opened blossom. "What ever has become of the sepals?" you will say. What indeed! The ungrateful bud, forgetful of their past care, has kicked them off! The poor things, mindful of duty, fitted very tightly together on to the fast swelling bud until it caused them to split away from the flower-stalk. They hung on for a bit like a green cap on the red petals and then fell.

**Petals.**

The petals number four or six, according to the presence of two or of three sepals, and the outermost are the broadest. Observe how they are crumpled away inside the bud instead of being smoothly folded one over another.

Perhaps this is caused by the tightness of the sepal cap, and we may see if it is so by examining very young buds. Once apart, they seem to catch every breath, like clothes drying on a line; and they gradually smooth out though they never look quite ironed, any more than clothes do, be they never so shaken, if they have long been huddled close together in boxes without being folded.



Arrangement of poppy sepals and petals (Le Maout)

**Stamens.**

As has happened already in so many of our studies, our efforts to count the stamens are baffled, but we can study the character of individuals. The pollen bags, for instance, join on to the stalks at their base, whereas if the flower were dependent on wind for fertilization, they would probably be suspended by the middle of their length, as we saw in the wheat. Thus does a trifle tell a tale.

**Pollen bribes.**

We begin to look for honey but cannot find it. Yet the stamens are so rigid and the signals are so bright! Probably if we watch the flowers we shall see flies and beetles crawling about them, and the bees flopping down on a convenient landing stage—the flat-topped pistil! What do they carry away? Look at the "baskets" formed by the hairs on the bees' legs, and you will see great lumps of pollen which they carry to the hive and store away for feeding the brood.

Poppies offer insects yet another bribe; they form snug lodging-houses on damp cold nights. Even Humble bees find room in the great opium poppy. See what insects you can find inside the little red poppy cousins.

**Self fertilization possible.**

However the flower does not depend on these visitors; the inner stamens are grouped so closely round the odd pistil that pollen is bound to fall upon it. To what extent are successful plants thus produced? This question might be answered in time by comparing the respective offspring of self and cross-fertilized plants. We expect the latter to be the best because

we remember that all ambitious (viz., rather complicated) flowers have taken great pains to secure cross fertilization; and the larkspur is even reckless and go-ahead enough to rely entirely upon it. We have also learnt that pollen brought by bees, so long as it comes from a similar plant, is sure to find its way down to the receptacle where the seeds originate.

**Summary.**—There are several wild poppies, the yellow perennial, the red annual, the white opium, from which numerous garden varieties have been derived. The white milky juice has sleep-giving properties. Insects visit the flower for the sake of (1) pollen; (2) shelter. Self fertilization is, however, quite possible. The petals number four or six, and the deciduous sepals two or three.

**Art.**—Charcoal outline and brush studies of poppies (leaf, flower, blossom and bud and seed-vessel). As a guide to designs, see Haité's line studies of the poppy and of the double poppy.

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## 63.—POPPY SEEDS (2).

(*FOURTH WEEK IN SEPTEMBER.*)

### Seed-case shapes.

This is a very different looking seed-case to any we have yet seen. It is like a jar or bowl, with flat projecting lid, and in the case of the Welsh poppy, it lengthens out tall and thin into a candlestick form. If possible, let the giant seed-case of the opium poppy be used for careful examination. We have to find out how such an odd-looking thing can possibly be composed of pistil leaves; and this will be a very difficult matter.

### Colour transitions.

To begin with an obvious and superficial characteristic: the lid is green, like the bowl; but from its centre rough velvety ridges radiate like the spokes of a wheel, and each ends in a lobe on the margin of the lid. These ridges are for catching the pollen, and once they have fulfilled their task they

put on holiday clothes, changing from green to yellow and from yellow to wine red.

**Compound pistil.**

Can the children discern ridges on the side of the bowl? There is one corresponding to each of the brown lines on the lid, eight and upwards on garden seed vessels, and five on the wild Welsh poppy head. What about the scarlet cousins?

Now for the meaning of these ridges. It will be found, on cutting sections of young vessels, that they correspond to the number of divisions within; but when the seed-case swells the partitions get pulled away from the centre, and all the rooms get thrown into one large cavity. The seeds grow thickly on either side of the partition walls, not, as usual, in rows indicative of leaf margins; so it is very difficult to make out where the leaves which form the bowl begin and end. A partial explanation will be intelligible if the children remember about the tissue of all leaves, as instanced by the clearly marked inner and outer skin of rhubarb sheaths. Well, the inner skins of the poppy's pistil leaves is more elastic than the outer skin; the latter merely thickens the bowl, and is then left behind, with just the mid rib of each leaf discernible on ripe cases. The inner skins grow on towards the stalk which runs up through the middle of the bowl. In fact, the inner skin of two leaves fold edge to edge and form a division. Each partition, therefore, is composed of two inner skins belonging to two pistil leaves, placed against each other. (It will be hopeless to expect children to understand this difficult morphology unless they make paper models. It will, perhaps, be wisest not to attempt to explain the lid at all. On the other hand, to shirk the whole subject would be to cast doubt on fundamental notions concerning origins.)

**Madcap posies.**

There are, then, as many pistil leaves as there are partition walls within and ridges without the seed vessel, and this number we know is variable. We found that the number of sepals and petals is variable also. In fact, poppies are madcaps, lawless things, reminding us, in this respect, of no family which we have yet studied. Let us pass on to other points.

### Independence of parts.

We remember that in the rose family the sepals are not altogether unconnected with each other, and they will not pull away cleanly. The melon flower consists of still more connected portions. On the other hand, the members of columbines and of buttercups are quite free. In the poppy, as in many another flower, only the pistil leaves unite. It resembles the columbine in having a "superior" seed-case. It is raised above the flower circle by a neck which is a distinct continuation of the flower stalk, and goes on to form the central shaft of the seed vessel.

### Exit of seeds.

Do the children know how the ripe seeds escape? We know the vessel never softens like fruit, of which the seeds are dispersed by birds, and it would certainly never do for such a big case to fall *with* the innumerable seeds; this would mean choking quarters—a regular Black Hole of Calcutta—for the seedlings. By the way, what happens if seed falls very thickly? The seedlings may never grow to more than an inch, yet they flower and go to seed. Thus a generation of dwarfs might be developed if there were no devices for dispersing seeds far and wide We must look for very ripe heads if we wish to see how the seeds really escape. Behold! windows open below the lobed eaves of the "lid"! There are two ways of explaining this marvel. Some say the sides of the bowl shrink away from the lid when the tissues dry up.

Others, that the substance of the stalk expanded all over the pistil leaves, and left off in a wreath of rounded lines which form the window margins. These lines accentuate; in other words, openings are left by the outward swelling of the pistil. This explanation is supported by the evidence of yellow water lilies.* Look at their similarly shaped seed vessels. When ripe the green stem expansion begins to separate from the backs of the pistil leaves to which it was originally fastened. It splits off from below upwards, so that you can quite see that it has nothing to do with the real seed case.

**Few survivors.**

How many hundred seeds do you think the large seed-case of an opium poppy is likely to contain? Nearly 3,000! A single plant may yield 32,000 seeds, and if all descendants flourished, the surface of the whole earth would be covered in four years. Perhaps we shall some day live in such a world of poppies. Why not?

**Survival of the fittest.**

Because these poppy seeds are wingless, they cannot fly away, but fall thickly and choke each other. Throughout the world the weakest die, whether they come up on ploughed land or in the fields, where the grass—like people who adopt professions early in life—has the first start. Only the very strong prosper.

**Variation caused by drought, etc.**

What happens if we do not water seedling poppies? They grow dwarfed, just as they do when sown too thickly. Also their faces get pale. Similarly garden poppies, self-sown, dwindle, become single, and lose their bright colours. Is there another cause which sometimes contributes to degeneration? Yes, they may have been crossed with wild or poor specimens. When gardeners wish to secure good seed they do the fertilization themselves, so as to ensure a cross between good plants only. How would the children do this bee's work?

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* Do not attempt to understand this matter without the seed vessels of yellow water lilies for illustration.

**Summary.**—The parts of poppy are irregular in number, and free, but for the pistil. The inner skin of the pistil leaves doubles back to form partitions. The seeds escape through windows under the roof of the pistil. The seeds are extremely numerous, and poppies are liable to degeneration from crowding, drought, and crossing with inferior specimens.

**Art.**—Design in brush work based on preceding studies.

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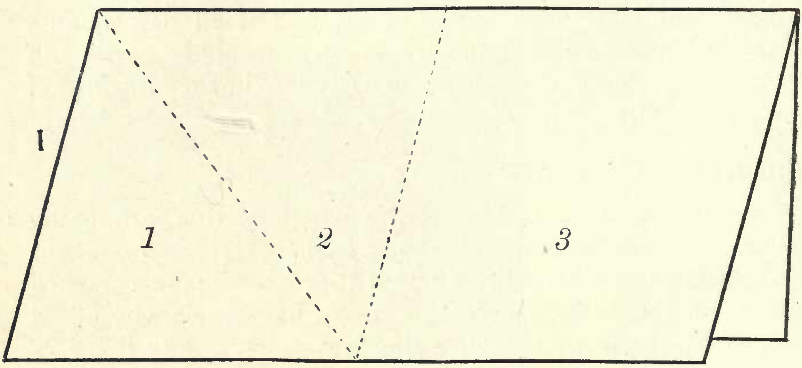
## Diagrams of Poppy for Cutting and Folding.

### SECTION OF A POPPY SEED VESSEL.

Cut in Foolscap and Brown Paper.

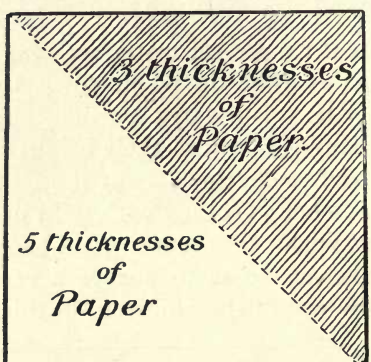
(*The white paper represents the inner skin, and the brown paper the outer skin of the carpel.*)

I

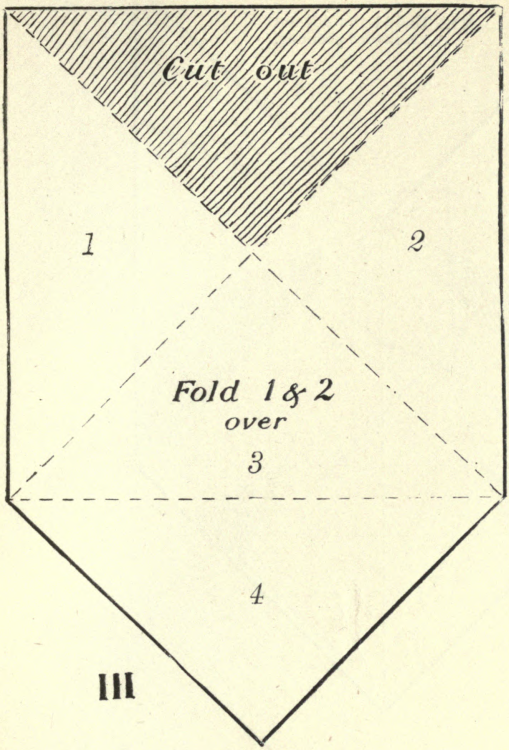



I.—Fold a large piece of paper in two, crease uppermost. Fold **1** over **2** in order to ascertain the limits of a square. Then unfold and turn the square backwards over **3** to obtain a 4-fold square. Cut away all paper lying beyond this four-fold square.

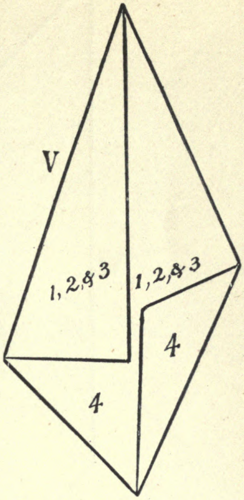
II



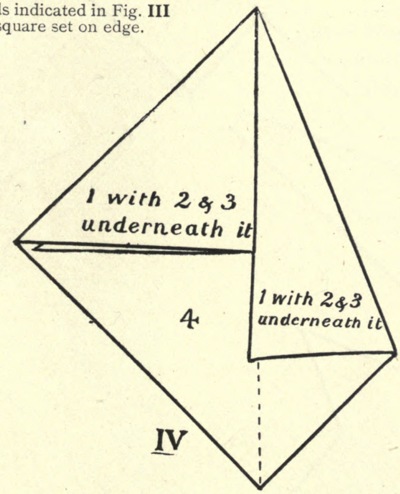

II.—Fold back one of the free corners of the four-fold square, and cut the shaded half.




**III.**—The folds indicated in Fig. **III** obtain a square set on edge.

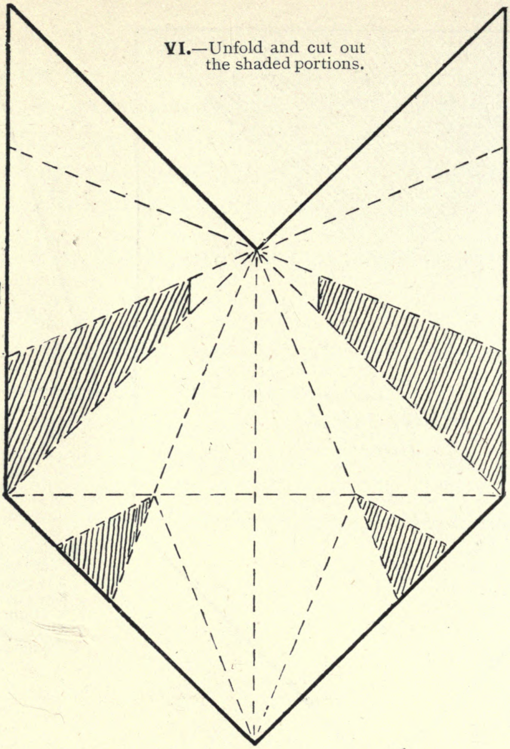



**V.**—Turn over the bottom sides of the square towards the centre as indicated on the right (only) in Fig. **V.** Cut out a piece of brown paper the same size as the folded figure.

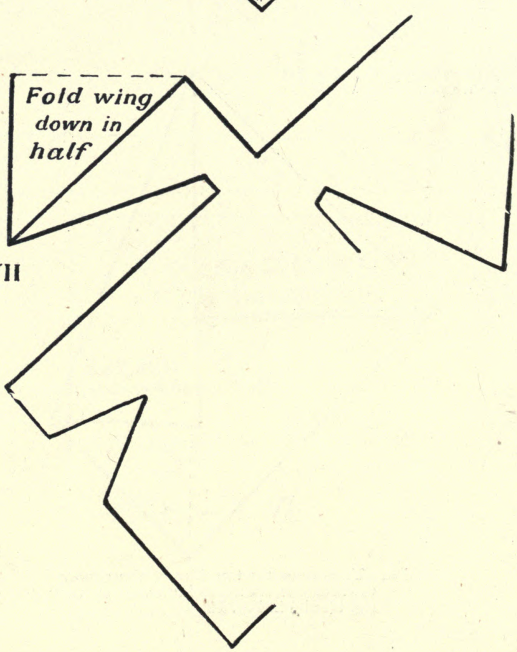



**IV.**—Turn over the top sides of the square towards the centre as indicated on the right (only) in Fig. **IV.**

**VI.**—Unfold and cut out the shaded portions.



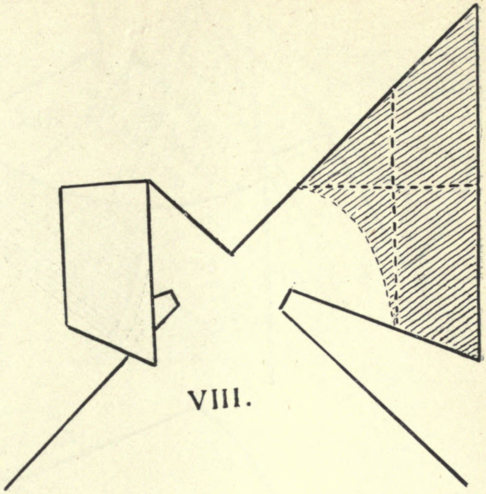
VI



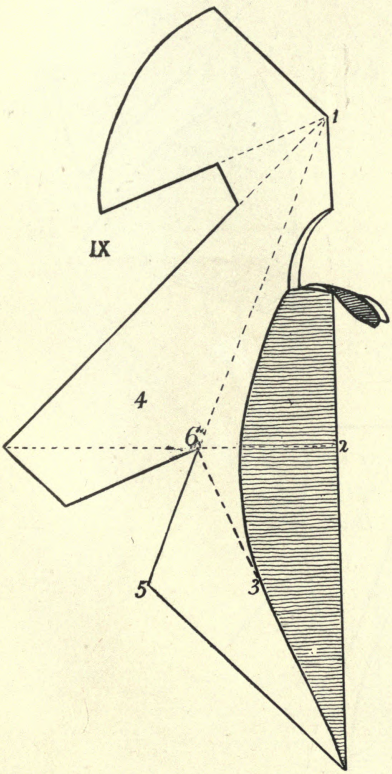

VII

**VII.** — Fold down side pieces as indicated.

**VIII.**—Fold each wing over again downwards as indicated on the left in Fig **VIII.** The resulting creases give the direction of the curved line shown on the right in Fig. **VIII.** Cut off the shaded portion.

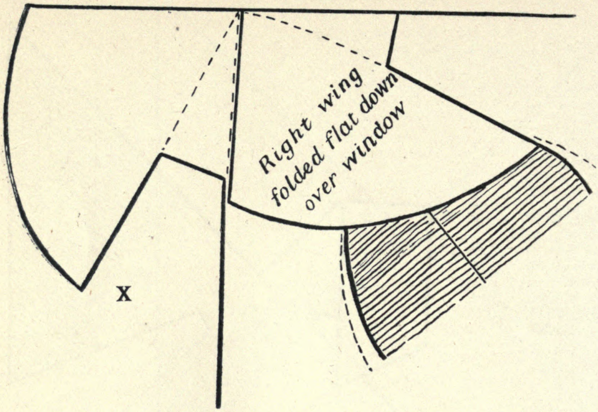


VIII.



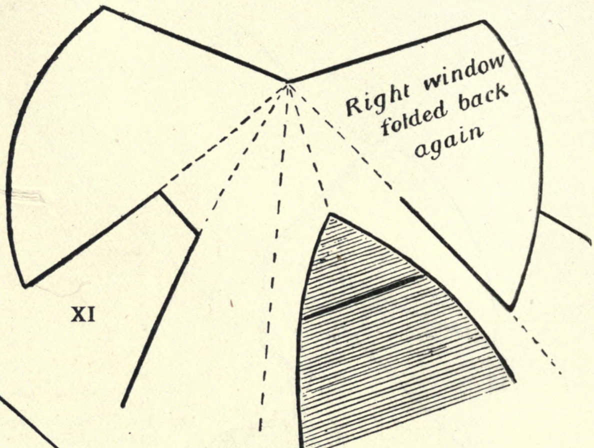

IX

**IX.**—Pin the brown paper (represented in figure by horizontal shading) on to centre of model. Fold the model in two as it is shown in Fig. **IX.,** and make a curved nick through with the brown and the white paper. Turn down the tongue and a window results; it is an aperture for the exit of the ripe seeds. The base of the window should be about half-way between points **1** and **2.** Trim the brown paper to the shape shown in the figure.

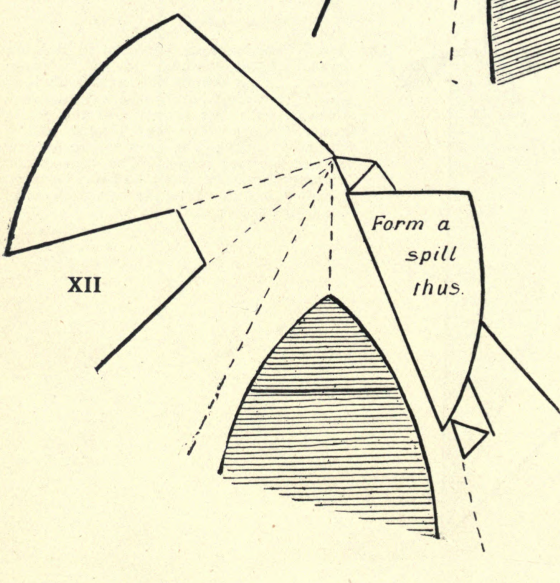



X

**X.**—Spread the model out, close the window for the time, and fold the wings over the brown paper as shown in **X., XI., XII.**

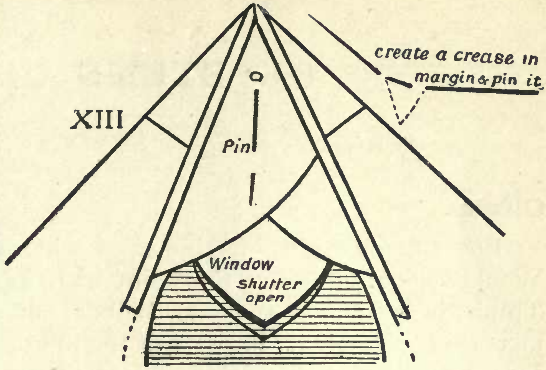


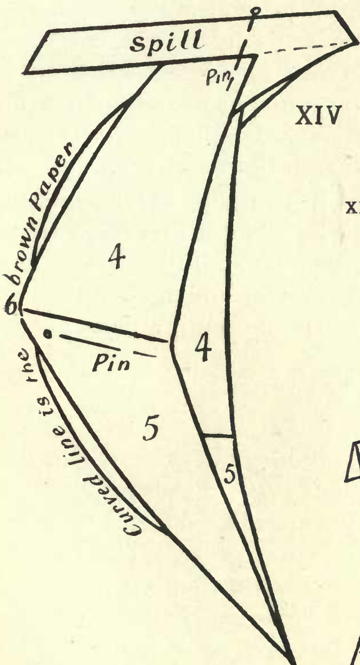

XI




XII

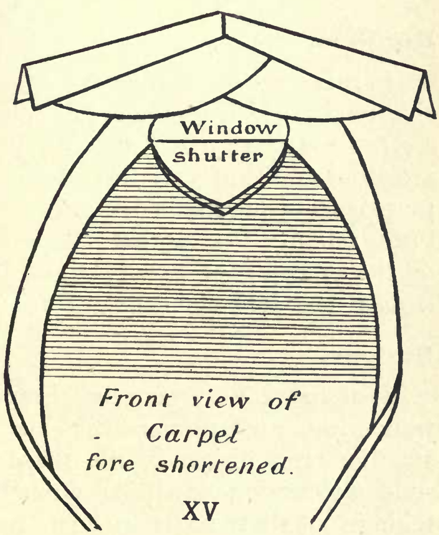
**XIII.**—The crest of the spill on either side is indicated by a double line, and the two folded wings are pinned back on to the centre of the model, above the open window. Then create a crease in the margin of the model at each side and pin it.




**XIV.**—Pin together **4** and **5** (see Fig. **IX.**) and flatten **6** with a thumb pressure on both sides of the model.

Profile of complete carpel.




**XV.**—Front view of completed carpel. One or two more may be made and all pinned together. See diagram of completed orange section, Study **72.**

# 64.—STEMS (1).

(*FIRST WEEK IN OCTOBER.*)

**Offsets.**

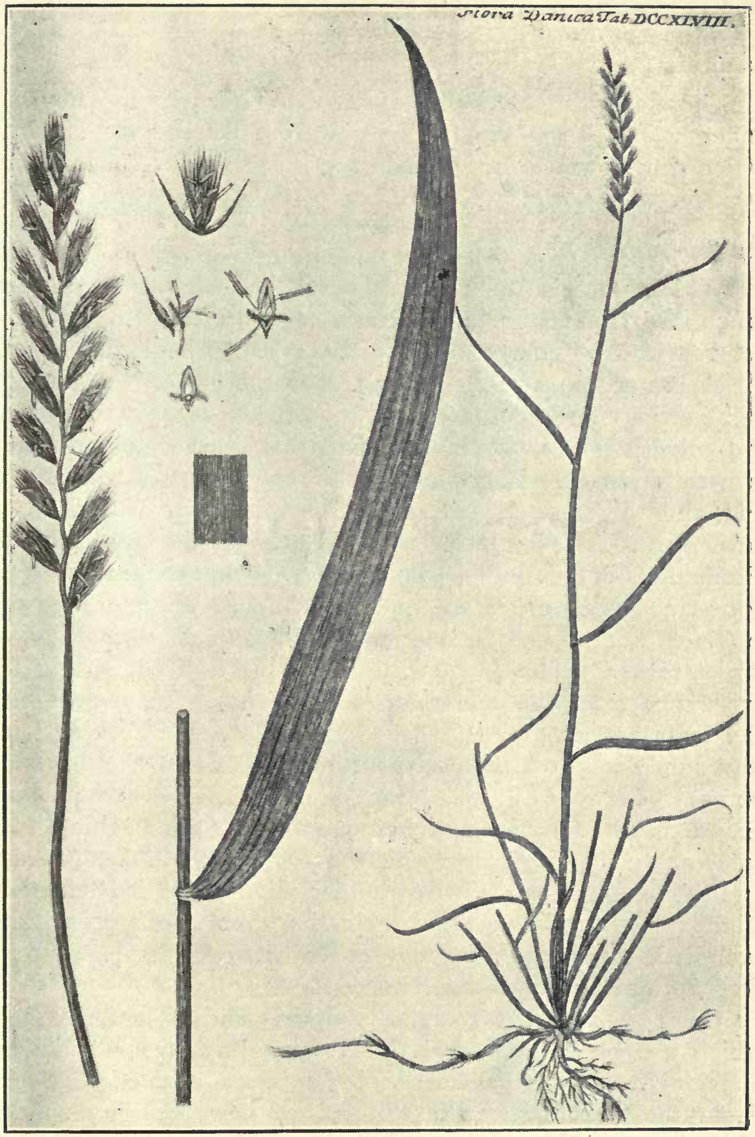
Let the children imagine a world cf seedless plants. Would vegetation be on the point of dying out? Why not? Think of runners, suckers, bulbils, etc. How do bulbs increase? Chiefly by bulblets in the joints of the scale leaves. Imagine a slender stem intervening between these bulblets and the parent bulb. This is what happens in montbretia plant. *Cf.* the common house-leek. Its thick fleshy leaves betray a double nature, and they grow so close together, with so little stem between, that the fat shoot reminds us greatly of a bulb. It seems half way between tightly-closed underground leaves and ordinary foliage separated to catch light and prepare food. The leaf buds produce stems which run out some way, and then form young plants at their tips. They wither away when the young plants or offsets have grown enough root to support themselves. Young bulbs at the ends of underground stems are also called offsets, and they certainly remind us of house-leek buds.

**Runners.**

Is this method of increase at all like anything which the children have heard of before? What is the difference between a strawberry "runner" and an overground "offset"? They are stout and thin varieties of the same thing. The runner, moreover, is quite naked, except at the tip, where it roots and forms a bud. What other runners have we studied? Those of the creeping crowfoot; these latter, however, often start from a leaf bud some height above the ground.

**Stolons.**

Perhaps you have seen branches which were slender, wandering, and runner-like; all clothed with leaves, and starting even higher in life than the crowfoot runner, then suddenly curving down far enough to reach the ground, and taking root there so as to form new plants. These are what




Couch Grass.

gardeners call "stolons," and they sometimes assist nature by pegging the shoot down. Young gooseberry and currant bushes may be thus obtained.

**Suckers**

These are just the reverse of stolons. For why? They are underground stems which rise upwards, instead of branches which sink downwards. (See lesson on briars.) A stolon is a sucker upside down.

**Rootstocks.**

Which grass is the farmer's curse, because cattle will not touch it? Couch, or quick grass. "Why don't the farmers get rid of it?" some of you may ask. Others may reply, "Because creeping roots run all over the place." Are these white stringy underground parts then really roots? Compare the corresponding but more evidently jointed underground growth of sedges. Each joint is provided with a root and a bud, and therefore, if separated from the rest, will form a new plant. The children may remember that one of the distinctions between a root and a stem, is that the former does not bear leaves, nor, in consequence, buds. Therefore we are looking, not at roots, but at underground stems called "rootstocks." The real roots, let it be noticed, spring by preference from the underside of the *joints*. In some kinds the buds are produced by the scale leaves; in others, the leaves only take on themselves this office when the terminal bud gets destroyed. The latter, as a rule, grows roots and leaves, and its tail of stalk rots away from its joint behind, like some nasty coggling worm which draws itself rear headwards, and then goes on again. No wonder the farmers are defeated. The humble meadow grass is a blessing instead of a curse, and each little tuft of roots is content with its own little spot, and does not grasp after new territories.

Compare now the rootstocks of iris and Solomon's seal, which are very short and thick, spreading from terminal buds only. From what does Solomon's seal derive its name? From the scar left by the tail-end of the sprouting shoot, where it rots off from the rootstock. (Circular lines are also left by the bud scales.) Lastly, compare the immensely thick rootstocks of cow's comfrey, grown in some places as fodder, or of horse radish. Why, if we were cleaning either of these

plants out of a bed, would it be fatal to leave a chip of rootstock in the ground? What advantage is there in cleaning land of knowing the difference between rootstocks and real roots?

Real roots, if left buried in the soil, so long as they are roots *only*, will shrivel up and die, there is no danger of their producing buds and sprouting again.

**Gardener's devices.**

The gardener does not invent, he only adapts natural methods. How, for instance, does he propagate plants otherwise than by sowing seed? He divides rootstocks; he "takes layers," in imitation of stolons; for he pegs down the end of a branch, and perhaps slits it partly, because a wounded surface produces roots more readily than a sound one. He also takes advantage of the stem's ability to grow roots, by taking cuttings. Let it be noticed that it is not the stem which springs from the root, as is often supposed, but the roots that spring from the stem. A clear understanding of these apparently fine distinctions makes the difference between a good and a bad gardener. A good gardener will not attempt impossibilities.

**Summary.**—Plants may increase as follows:—(1) By offsets, or buds produced at the tip of a short stem which connects them temporarily with the parent plant. Ex-house leek and montbretia: (1) (2) (3) the former producing plants at the tip of an overground stem; the latter bulbs at the tip of an underground stem. (Ordinary bulbs increase without this intervention of a stem.) (2) By runners which are very long, slender, tendril-like overground offsets. (3) By stolons, or aerial branches which bend down and root at the tip. (4) By suckers, which are underground branches that ultimately shoot upwards. (5) By rootstocks, or underground creeping stems, which send up annual shoots either from every joint, or else from the tip; in which latter case the side buds, if any, only shoot when the tip is destroyed; the buds, if cut off separately with a slice of rootstock, forming new plants. Gardeners, therefore, increase rootstocks by division and by suckers. Cuttings and layers (artificial stolons) also form new plants thanks to the stem's power of producing roots.

**Art.**—Let the children attempt to draw on the blackboards or on their slates (1) A young strawberry plant attached by its runner to a parent plant. (2) A young bush growing at the end of a stolon. (3) A young bush formed by a sucker. (4) Connected tufts of quick grass. Each attempt should fill the slate, and may be of the rudest nature, a mere diagram of the essential facts as stated in the summary above.

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## 65.—STEM TUBERS (2). The Potato.

(*SECOND WEEK IN OCTOBER.*)

**Culture.**

What do the children think potatoes are? From what part of the plant do we get them? At what time of year do we dig them out of the ground? Some are taken up just for use throughout the summer, but the main crop is dug up in the autumn. What do potato leaves tell us when they turn yellow? Not that the plant is going to perish, for we know if it is left undisturbed that it will come up again next year; but that it is about to "die down," *i.e.* all the sap or plant food which the leaves have prepared during the summer has migrated through stem to store-rooms. Are the potatoes, then, store-rooms? Well, so you may conclude if you consider the difference between those of autumn and of summer. This year's "early potatoes" were not all dug up, and those which remained underground have evidently been hard at work filling up ever since. "Early" or "new potatoes" are but half-stocked store-rooms.

**Storing and Sprouting.**

What is done with the potatoes when dug up? They are stored away in a dark place, and in early spring they have to be "sprouted." What does that mean? White smooth little shoots appear on the potatoes, and these have to be taken off. Are they bits of root or of stem? We shall see presently.

**Seed Potatoes.**

If all the potatoes have been dug up, where is next year's crop to come from? What are "seed potatoes"? They are

some of the best potatoes, dug up in autumn and kept for planting again in the spring. Why do we make work by taking them out of the ground? Because they cannot stand frost. (Those children who remember their English history, know that it is not an English plant.) If seed potatoes are "set" too soon the young shoots get caught by the frost, turn black and shrivel.

**Potato nature.**

Are the seed potatoes put in just as they are? What are "sets"? Large potatoes are usually cut across, and are then called "sets," viz., potatoes fit to be "set" or planted. Smaller potatoes, uncut, are also used as "sets." Perhaps the cutting of potatoes reminds us of horse radish and comfrey plants sprouting from cut slices. Like them, then, these potatoes produce buds and shoots. They must actually be a form of underground stem, and are called "tubers." The potato buds are called "eyes," and each "set" must have some good eyes to produce a healthy plant. Surely, like other buds, they are produced in the joints of leaves. Equally surely, the children will declare that there are no leaves upon a potato. But very tiny scales will be found on careful examination. They lie flat against the stem (or potato)! The winter sprouts, about which we wondered just now, are young shoots produced by the eyes before they are needed.

**Artichokes.**

The Jerusalem artichoke is another plant which has these "stem tubers" (thickened root stocks or portions of root stocks). Like potatoes, whole or cut "sets" are planted, chiefly in March and April.

**Earthing up.**

So soon as the young shoots appear above ground, what is done? They have to be "earthed up" (except on very dry soil, where deep planting is often preferred to "earthing up"), that is to say, the soil is piled up round their base, leaving only the uppermost leaves free till it reaches the height of six inches. Why is this done? We have seen that the young shoots grow from eyes, but where are the new potatoes to come from which we shall expect in a few months' time? Since

potatoes are stems, they must be produced from buds, and these buds must be underground on the earthed-up stem. Do these buds, then, which otherwise would produce branches, grow into potatoes at once? No, the bud starts underground as a slender branch, and only thickens into a potato at its tip. If possible, the children should carefully examine a clump of potato "roots" (really stems) freshly dug up, or, better still, let them dig a few up for themselves. They ought to find answers to the following questions, addressed by Bailey to American school children (see "Lessons with Plants," p. 366):—

"Do tubers grow above the roots or below them? Does this vary in hard and mellow soils? Do they form on the very end of the underground stalk? Does one stalk ever bear more than one tuber? Do tubers form successively on a stalk, or does a stalk ever branch? From what part of the plant do these stalks spring? Is there ever a stem upon both ends of a potato? From what point do the roots of a potato first spring, from the old 'seed' tuber or from other parts? If an entire tuber is planted, do all the eyes grow?"

**Summary.**—The potato and Jerusalem artichoke have parts of their underground stems enormously thickened into "stem tubers." These bear "eyes" or buds, which produce young shoots. A piece of tuber with one or two good eyes will produce a new plant, and is called a "set." Young shoots are earthed up so that the lower buds produce underground branches which thicken into "tubers" (artichokes and potatoes).

**Art.**—Outline studies on blackboards or slates of the various parts of a potato plant.

# 66.—ROOT TUBERS (3).

(*THIRD WEEK IN OCTOBER.*)

**Tap and branched roots.**

What is meant by a "tap-root"? Those who remember their study of seedlings will be able to answer. It is a root which grows *straight* down into the soil and gives off five side fibres, none of which approach the parent root in size. (*Ex.* dandelion.) On the other hand, the roots of grasses and of many crowfoots are *branched*—there is no central main root. Compare the growth of a fir-tree with that of a currant bush.

**Biennial taproots.**

Enumerate kitchen garden plants with taproots. Very thick are those possessed by turnips, beet, radish, carrot, parsnip, salsify, etc. Is their function similar to that of the slender fibres? It is hardly likely that they should look so different if they achieve the same end. As a matter of fact the rootlets absorb raw food material from the ground, while the taproot stores up prepared nutriment. It is a store-house, but, unlike the underground stem it produces no buds and is therefore a true root. It carries the plant through unfavourable seasons and enables it to blossom directly congenial weather arrives. Most plants with thickened tap roots are biennials, putting out leaves in the first year which prepare food supplies against the second year's blossoming. Compare the roots of kindred annual, biennial, and perennial plants (such as those of columbines, poppies, etc.) and see how the difference lies in the thickness of the taproot.

**Branched and crown tubers.**

Taproots are not only of varying thickness but of varying shape also. The turnip root is round, the carrot tapers to a point, the radish is thickest in the middle. The top part from which leaves spring is, remember, stem, not root. It is called the *crown*, and these plants are said to have "crown" or

"root tubers"—just as potatoes and Jerusalem artichokes have stem tubers.*

**Fibrous roots.**

Branched roots, when they are slender like those of the crowfoot, are said to be "fibrous." They are annual, absorbing food merely like the fibres on biennial roots. Sometimes, however, as in the dahlia, a portion of them may thicken into tubers and are then called biennial.

**Perennial, biennial and herbaceous stems.**

Nature seems to dislike hard and fast lines: every rule is subject to exceptions. For instance, do *all* biennials die down in winter? Wallflower plants retain their leaves all winter time—their roots are very slightly thickened in consequence. The kohl-rabi stores food in its stem; the cabbage, in both stem and head of leaves. What about perennials? Trees and shrubs store food in their woody stems. Soft stems that cannot stand the winter are called "herbaceous," that is to say, "belonging to herbs." Herbs with perennial roots or underground stems are called "herbaceous perennials."

**Connection between annuals and biennials.**

The children may remember hearing in one of last year's lessons how garden carrots have been developed from wild annual carrots in four generations by means of sowing the latest seedlings. These, having no time to flower before winter, enlarged their roots instead. Other garden biennials

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* The sweet potato need not be mentioned if the children have never seen it. But in case they should be familiar with it, they should understand that it is another root tuber, as we may tell by its fibrous roots (where do stem tubers put out fibres ?). We must not be deceived by a very exceptional freak—unlike any root we have ever come across, it sometimes produces buds, especially upon its upper part. It then seems a transition form between root and stem, corresponding to the transition forms which we have studied in flowers. Buds thus produced in unusual places in no regular order may be called "chance buds." They may often be seen sprouting on old tree trunks.

have similar histories and may at any time "run wild," that is to say, flower and die in the first year instead of putting all their energy into stocking the root. Further, many plants may be perennial in countries of milder winter which in England are annuals and rely on seed for continuance.

**Summary of three preceding lessons.**

Plants which live through the winter are either perennial or biennial shrubby plants or biennial and perennial herbaceous plants. In either case the food prepared for starting next year's growth is stored either in root stocks, stem tubers, or root tubers. The two former produce buds and increase the plant. Root tubers may be of two kinds, (1) taproots (or crown tubers or root tubers); (2) branched roots. The latter rarely produce buds like stem tubers, but give off fibres just as taproots (but never stem tubers) do. Annuals have either slender taproots or slender fibrous "branched roots."

**Art.**—Let each child draw simple outlines of as many different *kinds* of roots as he can call to mind.

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## 67.—TOMATOES.

(*FOURTH WEEK IN OCTOBER.*)

**Tomatoes are berries.**

What *is* a tomato? A child who describes it within as well as without may remember that it contains seeds. It is, therefore, a pulpy thoroughly soft seed case, properly called a "berry." Are gooseberries, currants, cranberries, grapes, strawberries, blackberries, and raspberries, real berries or not? (Of course the three last are misnamed, see lesson on strawberries.)

**Cultivation has produced varieties.**

Do the children know whether there is more than one kind of tomato? Seventy or eighty sorts have been established in

the last 100 years, thus proving how rapidly a number of varieties arise when a plant is widely cultivated. Let as many of these as possible be compared; also different specimens of the same variety. Size, shape, and surface are influenced by internal features, so cut the fruit across. The number, size, and shape of cells vary greatly. We have before now found the seed case to be a very inconstant member. Still, no two tomatoes of the large fruited garden kinds are quite the same, and we are at last tempted to think they must be monstrosities —the unnatural results of cultivation. Some kinds, however, vary more than others, and the least variable we may take to be the least monstrous—*i.e.* the nearest descendant of the wild species, which does not grow in England.

**Cultivation increases the number of pistil leaves.**

The cherry tomato is small, berry-like, and least variable of tomatoes, being closely akin to the wild fruit. Sometimes, however, its two cells become three or four, and here we see first stages of monstrosity. The big tomatoes do not owe their size merely to a thickening of the walls, but to a still greater multiplication of cells. Let the children recapitulate what are the changes in condition implied by "cultivation." High feeding, space, protection from all danger—selection of survivors by man instead of nature. Let them instance observed results such as size, double flowers, transformation or addition of parts, etc.

Now, in the case of tomatoes, the gardener does not wish to grow show flowers, but tasty fruit. So, instead of encouraging petals, he causes pistil leaves to multiply. Other fruits involve the growth of other parts, as the children themselves may explain.

**Smooth tomatoes.**

The addition of new cells has caused tomatoes not only to swell but to change shape. Old-fashioned tomatoes are "rough"—external furrows betray the number of pistil leaves (*cf.* poppy heads). Then smooth tomatoes were preferred, and the seed of the smoothest always saved. The pistil leaves are numerous in the modern fruit, but very small (thus obviating deep external furrows), and many squeeze themselves into the middle of the berry. This results in the fruit

stretching and splitting above. The "Turk's Cap Tomato" exhibits a further stage—some of the extra pistil leaves get thrust out at the top of the fruit and give it its name.

**Loss of seeds.**

Many-celled tomatoes often produce little, if any, seed. As usual, the unnatural flower cannot carry out the purpose for which Nature intended it. Also delicate, high-bred fruit is much more liable to disease (called "fruit rot") than the old cherry sort.

**Degeneration easier than development.**

Not only has man affected the fruit of the tomato, but also the shape of the leaves, and even the size of the whole plant. Compare the small, curled-in foliage of rough tomatoes with the larger, plainer, irregularly formed foliage of the commoner varieties and the great lobeless leaves of the "Mikado" and "Potato" tomato. The same causes which have developed the fruit on different lines have led to accompanying changes in the leaf.

**Relationship of potato and tomato.**

What common leaf are the children reminded of? The potato leaf! Look at the fruit for a trustworthy proof of relationship. The class may very possibly declare that the potato plant has no fruit. Yet, on its first introduction, the purple berries attracted more notice than any other part of the plant—people supposed they were to be eaten, and naturally were disgusted with Sir Walter Raleigh's discovery.

The potato and tomato plants show how very differently relations may be developed to suit man's opposite purposes.

The tobacco plant, another cousin, is grown for the sake of its leaves.

**Summary.**—Varieties of tomatoes demonstrate the rapidity with which changes may be effected by cultivation and selection. Quite different parts may be developed by similar means for similar ends. Tomato fruit is, properly speaking, a berry, of which the size has been increased by multiplication of pistil leaves, and the shape of the whole plant has been modified in consequence.

**Art.**—Outline brushwork studies of the tomato. See Haité.

# 68.—APPLES AND PEARS.

(*FIRST WEEK IN NOVEMBER.*)

**Recapitulation.**

Tell us, how do apples differ, not only in size, but in shape? Some are more furrowed than others above; some have shallow, others deep, depressions below. Do these external correspond, as in tomatoes, to internal variations Sections will prove. Meanwhile the class must be put through a little recapitulation concerning matters learnt last spring. Do they remember what the five little leaves are on the top of the apple? What other fruit wears a crown of sepals? How much of the apple is formed by stem expansion (from which the sepals spring)? Strawberries, rose hips, and apples, do not resemble each other at first sight, yet the edible part of each is the same, as it is also in pears. The lower part of the pear often resembles the flower stalk, making it easier for us to realize its true nature. Fruit, you see, is a term which may mean not merely a seed-case, but parts, such as the flower stalk, which have grown with it. What composes "core"? It is gritty to taste, and yet it corresponds to the juicy substance of apricot, being swollen pistil leaves. The hard membraneous shell which encloses the seeds must be the inner skin of pistil walls. What, then, does the boundary line mark which separates the core from the outer fleshy part? It is the outer skin of the pistil leaves. How many of these are there? How many seeds (or "pips") to each of the five cells?

**Monstrosities.**

Facts concerning the formation of fruits are very difficult to understand, and they are only proven by monstrosities. Do the children remember what a monstrosity is? It is not merely an unnatural freak, it is often a reversion to old-time forms—perhaps thousands of years old. Parts which are entirely different when "grown up," so to speak, may resemble each other greatly in their earliest baby stage,

and we can no more tell why they should alter later on, than why they should turn out so alike as to reveal relationship.

What did the strawberry monstrosity prove? Here are some equally instructive tales about pears and apples:—

1. A stem and tuft of leaves once grew on the top of a pear. Then the pear swelled and enclosed the stem, so that only the leaves remained visible.

2. Somebody else saw a much longer stem growing from the tip of a pear. It seemed to put out all its strength that way, and the foolish thing contained neither cells nor seeds.

3. Pear blossoms have been known to put out a flower instead of a leafy branch from their centres, and when the fruit of this second flower has "set" a double pear is the result. The stem connecting the two may be long enough to keep them separate, or it may be so short that the swelling fruit fuses more or less. Sometimes a three-storied structure has been seen, a leafy branch growing out of the centre of the second flower. In all, there is no proper core with seeds, the flesh of the fruit being solid throughout. In normal pears one can distinguish the bundle of woody fibres which connects the stem proper with the pistil leaves—here the wood can be traced right through the pears into the leafy branch beyond. (It is some outside layer of the stem which expands to form the fleshy part of the fruit outside the core.)

In all these monstrosities the pear proves itself to be swollen stem. But in normal cases it swells *around* a circle of pistil leaves, and afterwards carries circles of sepals, petals and stamens.

Now I want to tell you about a very queer apple-tree which once grew in France. The flowers consisted of neither petals nor stamens, but of ten sepals arranged in two circles above a pistil which, of course, could never be fertilized. The owner, in despair, determined to cut it down. Then stepped in the advantage of a friend's knowledge. He recommended the owner to fertilize the blossom with pollen from ordinary apple-trees. The experiment turned out very successful, and ever afterwards the neighbours came in

a party at springtide, and each brought pollen to fertilize particular flowers, and tied a ribbon to them so that they might be known again. The fruit differed in size, colour, and taste, according to the tree by whose pollen it had been fertilized. But all the apples agreed in a single respect: Each had a strange waist at about two-thirds of its length, thus reminding us of how one pear overtook and half swallowed the second. Now why should these apples have turned out double? Perhaps some of the children remember that there was a double row of sepals. In reality each now belonged to a different flower, but no stem had grown between the rows. At last the fruit told the tale. The bottom half of the ripe apple, if cut in two, displayed five ordinary cells; the upper half, nine smaller ones. They were mostly without seeds. Sometimes a tiny undeveloped leaf is produced on the side of an apple (reminding us of potato scales) thus showing its stem nature.

The children will readily understand that these variations are *unnatural*, because they hinder instead of helping the plant to perform its function of seeding. If, on the other hand, they had turned out to be of advantage to the plant, they would be fostered by natural selection and become normal.

**Summary.**—Apple and pear monstrosities clearly betray the nature of the fruit, which is an expansion of the stem round a circle of pistil leaves. These are borne on a woody continuation of the stem. The softer expansion carries on its crown: sepals, stamens, and petals. The sepals, and sometimes the stamens, persist.

**Art.**—Draw apples and pears whole and in sections, in coloured chalk and with the brush, and show positions of seed in the core.

# 69.—CRABS AND ALMONDS.

(*SECOND WEEK IN NOVEMBER.*)

**Wild apples and pears.**

There are no wild tomatoes in England; are there any wild apples and pears? All the children have probably tried to eat hard, sour, little crab apples, without ever thinking, perhaps, that they were digging their teeth into the venerable ancestors of all apple kind. The wild pear is less common than the apple, except in Worcestershire. At the beginning of the last century it had only forty descendants. Now it boasts of over 1000.

**Bird taste.**

What other ancestors of garden fruits grow wild in our hedges? There is the wild cherry; the wild plum, which is very rare; the sloe (from which some of our plums have descended); the strawberry, etc. Blackberries are now grown as a garden fruit, and, accordingly, have gained in size and sweetness. Now why should nature choose to make wild fruits small and sour? As regards size they must form a convenient mouthful for birds; not that any bird ever swallows a whole crab-apple—it picks out the pips instead. Size really seems to be one of the conditions of softness and sweetness—wild fruit never swelling to either of these latter qualities, because birds appear quite as well content without them. Yet Nature adjusts matters very nicely—a certain amount of ripening, and therefore of sweetening, takes place in wild fruit, as though there might be a point of sourness at which the bird would refuse the invitation.

The plant's ideal seems to be this: to grow fruit as honeysuckle does, too sour for anything except a bird. Some plants succeed very well, and are even poisonous to animals—such, amongst others, are the yew and the "deadly nightshade," (a cousin of potatoes and tomatoes).

**Almonds.**

But there are a few plants which will have nothing to do with birds at all. Like some proud and independent people they scorn attractive appearances. Their fruit is neither juicy nor showy. The apple has one such relation, a foreigner, which you have probably all cracked and eaten, the hard-shelled almond. We have never seen the whole fruit;—the part that reaches England corresponds to a plum stone—it is the inner skin of the pistil. But the part which has split away is not juicy like the plum fruit, but hard and dry and comparatively thin.

We know how difficult it is to get at the almond kernel, and we know that, if planted, this kernel would somehow have to break through its prison walls. This seems an impossibility, and apparently nature thinks so too, and therefore causes the walls to separate.

Do you remember the villainous apricot seed ? How it kills its twin brother and lives all its days shut up in the apricot "stone!" No prison walls separate for him ! He has to live in his dark cell until moisture of the soil gradually rots away the walls around him. Then only, after this long penance, is he able to sprout at last.

**Small apple-like fruits.**

Many so called berries really resemble apples and pears in structure; can the children suggest examples ? (hawthorn, mountain-ash, etc.). We find a hard middle portion composed of bony pistil leaves when we try to cut them in two. (*Cf.* structure of real berries, see Tomato Lesson.)

**Summary.**—Apples and pears, from which all the garden varieties have originated, grow wild in England. Like other fruits they differ from their garden descendants in being small or sour and hard, adapted for dissemination of the seeds by birds. Plants of different aim screen their seeds (if tempting to birds) by hard cases. (The almond is an example. Its outer walls, corresponding to the fleshy part of the plum, split away from the stone to free the kernel.)

**Art.**—Brush work studies of crab-apples.

# 70.—NUTS.

(*THIRD WEEK IN NOVEMBER.*)

**Persistent involucre.**

Let the children attempt to explain a beech nut. What is seed-case and what is seed? They will probably take as seed-case the rough outer husk which splits into four parts and contains two nuts in its centre. They may be disabused by the appearance of a hazel nut which is only half covered by something not at all resembling the leaves of a pistil. Now, does it occur to any of the class that the cup of an acorn is a corresponding structure? And it is clearly no seed-case. Furthermore, all these nuts agree in having a hard skin enclosing a single seed. The skin, therefore, and not the cup, is evidently the real vessel.

What, then, is the acorn cup, and what are the corresponding parts of the beech and hazel nuts? Close examination shows the former to be a mass of tiny scales, which in some foreign oaks are much larger and clearly betray their foliage origin. Similarly, the beech-nut is covered with four hardened leaves; the hazel and its near relation the filbert, with two only. If we examine the flowers we shall be convinced that these leaves are not sepals. What other kind of leaves have we ever found in the close neighbourhood of flowers—sometimes even encircling them? Stipules in the strawberry, bracts in the wheat, etc. Indeed, bracts are very often to be found on all manner of flower-stalks, just under the blossom, being simply reduced and otherwise altered leaves which serve to protect the bud. These outer coverings of nuts are likewise bracts.

**Prickly involucre of Spanish chestnut.**

The Spanish or sweet chestnut has a very strange outer covering of bracts. Perhaps one of the children can describe a chestnut "bur" from memory, in case there should be no example available. Outside it bristles with prickles, but within it is soft and velvety. When two or more nuts are

ripe the covering splits open into four parts, just as the beech nut does. We may find scales among the prickles, and if we remember columbine scales among the stamens, we shall not need to be told that they are just flattened and widened prickles which tell a certain tale about the origin and nature of all the rest.

**Characteristics of nuts.**

If we can make out in what respects all these nuts agree, we shall know a nut again wherever we meet one, under whatever disguise. All then are hard and dry—they do not split, and they contain but a single seed. In fact, they remind us of buttercup or strawberry seed-cases, only they are on a much larger scale and colonize under different conditions. If we could have examined them in their earliest baby stage, we should have found more than one seed, but these get squeezed out of existence like the apricot twin. The acorn is perhaps the most criminal of all nuts—it squeezes to death five brothers which always start life with it in three cells ! *

**Walnuts.**

We have learnt before that Nature draws no hard and fast lines.

The walnut is half-way between a nut and a stone fruit, having the stone of the latter but not the flesh. Still it is much softer than true nuts. One must not be deceived into thinking that the green husk corresponds to a beech or chestnut "bur."

**Means of protection.**

What was Nature aiming at when she covered nuts with bracts and hard walls ? The green covering of an unripe hazel nut hides it from all foes, and when it turns brown and falls to earth it is equally inconspicuous. Again the prickles of the Spanish chestnut must keep off hungry enemies. Also the young nuts are wrapped up in a warm velvet-lined coat. But what about the acorn cup ? It can hardly be protective ;

* The children must not be allowed to mistake oak apples for the fruit of the oak. They are analogous to rose haws, being the swellings in which an insect lays its eggs. Later on the young grubs eat their way out, as may be seen by little round holes on the balls.

so we can only suppose that perhaps at some early stage of history it served a purpose, which changed conditions no longer require of it now. Or, perhaps it may serve some purpose still, and a clever person will find out what this is some day. What we must bear in mind is that we need not think to explain every detail of a plant with reference to its *present* needs and conditions. Conditions sometimes change faster than the plant. For instance, the seed-case of the walnut may be protective, but on the other hand it decays so slowly that the seeds have great difficulty in growing except under the most favourable circumstances. Also, though the seed-case effectually defeats the attacks of birds, it is powerless against squirrels. The hard case of the beech nut is not even thus far successful, for some birds feed on beech mast (ringdoves and wood pigeons).

**Summary.**—Nuts are hard dry fruits which do not split. They are single-seeded, but usually start life with more than a single cell, each of which contains more than one seed. Nuts are often surrounded by an involucre of hard persistent bracts which are sometimes protective. The walnut has a stone-like stone fruit, but the outer part of the seed-case is almost as hard as a nut.

**Art.**—Charcoal studies two or three times larger than life, to be made in simple outline of beech nuts, Spanish chestnuts, walnuts, filberts, and acorns. Guide to subsequent designs.

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## 71.—KEY FRUITS.

(*FOURTH WEEK IN NOVEMBER.*)

### Winged Sycamore seed.

What are the bunches of keys which hang, often three to a stalk from sycamore trees? On examination, each key will be found to contain a warmly covered seed at one end. Thus we unlock a secret. The shaft of the key is only a growth of the seed case, and we wonder, perhaps, why it has gone to so

much trouble. Any of the children who have collected butterflies, and especially moths, will, however, be reminded of certain wing shapes,—indeed keys are often called "winged fruits." Do they fly then? Stand under a tree in an autumn gale and watch how they snap from their stalks and whir away through the air. See at what long distances they strike the ground, and describe in what attitude they sit down patiently till coming frosts be past. They ripen in August or September, yet they are content to put off sprouting till the warm spring weather comes.

You see the rule holds good about a single seeded case not splitting, but falling and burying itself along with its solitary charge. It is just as if a parent could not part from an only child at any price, but must screen and guard it to the last.

**Elm, birch, maple and ash.**

Can one of the class mention other plants whose seeds are similarly dispersed? Elm, which ripens its seed in June, and birch trust their progeny to the *middle part* of a wing-like membrane. The maple bears twin key fruits resembling those of the sycamore. Ash keys are rather differently shaped, with this additional peculiarity—that bunches are formed on last years wood. How long, then, does the fruit take to ripen? There is none unripe in the leaf joints, so we must conclude that the buds we find there will push out keys next year. Compare other trees in respect to this method of fructifying. Herbaceous plants and shrubs never bear winged fruits, because they grow too low for the wind sweep.

**Horse chestnut.**

Last week, while studying sweet chestnuts, you must have wondered why no mention was made of the horse chestnut, and you probably thought that its prickly bur corresponds to the husks which you compared on beech and walnut trees, etc. But, no! the brown skin of the ripe chestnut is the hard skin of the actual seed, the prickly bur being the pistil coating. We mention it here because the horse chestnut (which has nothing to do with the sweet or Spanish chestnut) is closely allied to the maple tree. Both leaf and blossom tell this tale, however different an aspect the fruits may bear.

**Recapitulation.**

Let us recapitulate our lessons on fruits: they may be divided into two classes of dry and fleshy members respectively.

Dry fruits either split open and may be called "pods," or bury themselves with a single seed (*ex.* buttercup, strawberry, rose, grain, keys, nuts, etc.).

Pods are usually many seeded and simply split down the edges of the pistil leaves (*ex.* columbine). *f.* methods adopted by crossworts and poppies.

Members of the same family may vary, such as the columbine and buttercup, the rose and the apple. In what does the seedcase of a cereal differ from that of a buttercup or a strawberry? A grain of corn entirely fills the cell, and its thin skin is joined to the very thin seedcase walls. Of all seedcases, this is the most liable to be mistaken for the seed itself.

**Additional Summary.**

Key fruits either have a long wing or shaft, like the sycamore maple and ash, or are comparatively round in shape with the seed perched in their centre, as in elm and birch. These wings float on the wind to great distances and fall heavy (or seed) end earthwards—the case burying itself along with the single seed.

Horse chestnut is allied to maple and sycamore, the green husk being a seed-case and not a husk.

**Art.**—Diaper Design of Key Fruits.

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## 72.—ORANGE FRUIT (1).

(*FIRST WEEK IN DECEMBER.*)

**The orange is a berry.**

The orange at first sight reminds us of no fruit we have yet studied, but perhaps an accurate description may help us to realize its nature better. Often to state a difficulty boldly and clearly means to overcome it. Let the children attempt an analysis for themselves.

Then they may be asked whether the part we eat is a stem development or a portion of seed case wall. The answer is readily obtained on dividing an orange into its natural sections —thin-skinned vessels of juice and seeds. They are the pistil leaves, of which the inner skin only (as in the poppy) has folded back. But despite divisions the orange is juicy and fleshy all the way through, like what other fruit? (Tomato, gooseberry, grape, etc.) Now, at least, we are reminded of formations kindred to that of the orange; and, to our astonishment, we may label it a *berry* in spite of its leathery rind.

**A poppy head compared.**

How does the cross section of an orange call to mind, in an equally unexpected way, some fruit already studied? The poppy seed case was similarly partitioned, but three great differences strike us. In the first place it was dry and the orange is juicy. In the second place the growth of the poppy divisions did not keep pace with the growth of the whole fruit, as here. In its old age the seed house contained but one room. Thirdly, poppy seeds broke the law: they grew all over the seed-vessel in an unruly fashion, consistently with the flower's character. But here they are produced in the usual order—two rows along the margins of each folded pistil leaf.

Notice how these edges are thickened, causing the white central column, usually called "skin." If it did not hold all the pistil leaves together (along with the binding rind), we might be reminded of columbine seed vessels. They also face inwards towards each other, turning their backs on the outer world, and they split down edgewise when the orderly seeds are ripe.

**Hair-like juice vessels.**

It was explained to the children long ago that all vegetable tissue, between its inner and outer skins, is composed of cells full of living sap; and they were recommended to hold up a slice of ripe orange to the light in order to see what these cells on a very large scale look like. Perhaps, on nearer acquaintance with the nature of orange fruit, they are wondering how cells come to fill the cavities of pistil leaves. We can watch the strange process from beginning to end by cutting open a succession of oranges. In the baby fruit the seed cavities are

very small, and both walls and edges of the seed leaves appear proportionately thick. The numerous seeds are set in two rows along the edges of each leaf—they are so threadlike and undeveloped that we might fail to recognize them but for their position and suggestive colour. There is no juice as yet, and facing them in the cavity is a lining of hairs. Now let us read chapter two of the story, as exhibited by an older orange—say the size of a grape. The hairs are growing longer, converging in couples towards the centre of the fruit. The seeds are growing to meet them; but the hairs find their way past them and finally meet the thickened margins of the folded leaf. Thus they have filled the entire cavity; and now they begin to swell out and reveal themselves as hollow bodies containing juice. They swell with increasing substance, and the walls of the cavity seem to shrink, and the seeds either ripen or wither away. The more unnatural the size of the orange the fewer the pips it contains and the greater the capacity of the hairs. They fill and fill like miraculous pitchers, till—unforeseen result to Nature's fairy tale! all the world is sucking oranges.

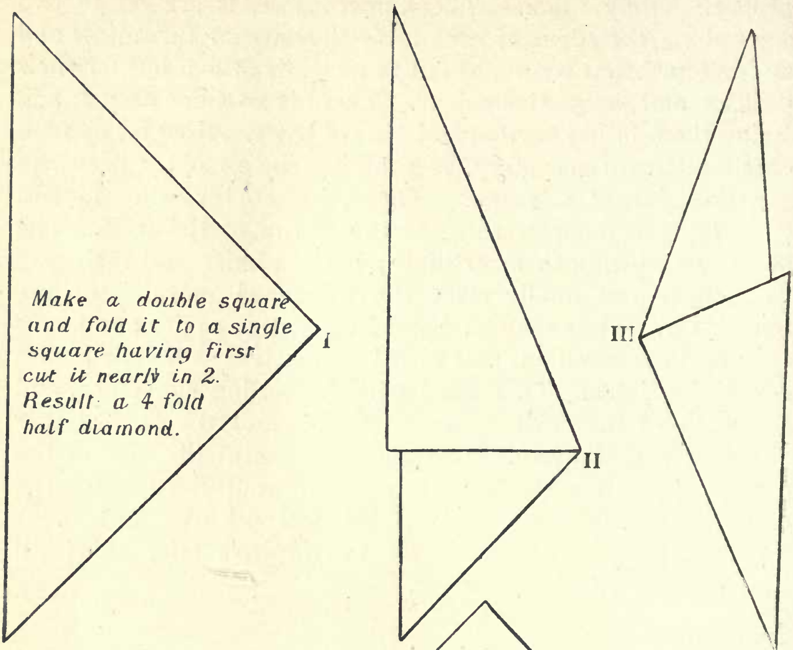
**Irregularities.**

Meanwhile we have watched the green rind change to gold: my lord orange has been tempted by man to live in a very big way, and we need expect no regular conduct of him whatever. We shall find the number of divisions (cavities or pistil leaves) varies from eight to fifteen; sepals and petals may be four, five, six, seven, or eight; and the stamens most often number twenty-five or some other multiple of what may have been the primitive figure. Under these circumstances you will not be surprised to hear of some quite extraordinary monstrosities during our next and last lesson.

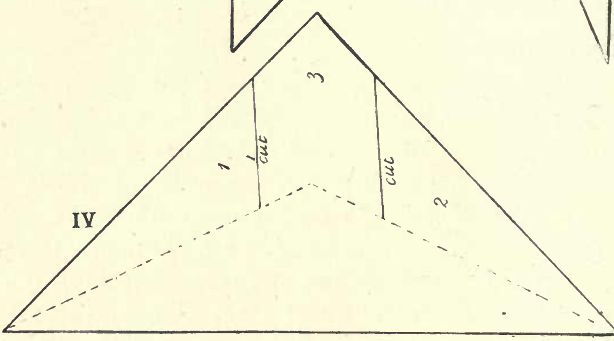
**Summary.**—The orange is a berry with a leathery rind. The pistil leaves, like the members of the outer flower circles, vary in number greatly. The inner skin of each (as in the poppy) folds back to form a cell. The united edges are very much thickened to bear the pips. While these ripen, juice is secreted by hair-like cells within the cavities of the seed vessel.

**Art.**—Cut and fold paper orange—fruit sections according to diagrams.

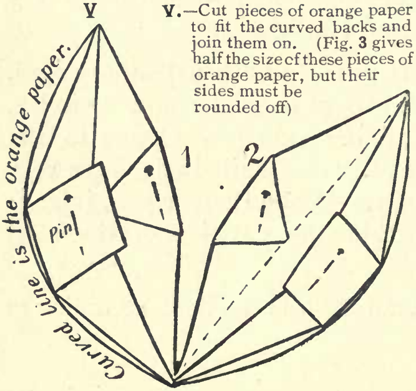
*Portions of an orange to be cut out in white and orange paper.*



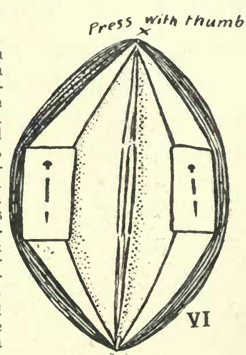

**IV.**—Unfold to obtain this halt diamond and cut as indicated. Then unfold the diamonds completely. Draw together tongues **1** and **2** on either side of each, and fasten **3** over them with a pin, thus bending the back of the models into a curve (as shown in profile, Fig. **V**)




**V.**—Cut pieces of orange paper to fit the curved backs and join them on. (Fig. **3** gives half the size cf these pieces of orange paper, but their sides must be rounded off)




**VI.** — Fasten **1** and **2** in Fig. **V.** together with a pin, and Fig. **VI.** will result, viz., two ripe carpels of an orange fruit. Four carpels may be attempted in stiffer paper with larger pins to make a model about the size of a man's head.



# 73.—ORANGE MONSTROSITIES (2).

(*SECOND WEEK IN DECEMBER.*)

Now we come to the limits of wonderland—to the end of our botany lessons. Strange are our last impressions, yet stranger, perhaps, if we only knew, are the everyday sights we shall see all our lives. Let us watch them always for our help and consolation, and the lessons of our childhood will not have been learnt in vain.

**Change of stamen to pistil leaf.**

But the class is impatient for its last school peep-show. ("Navel" oranges should be procured from a grocer, for illustration.)

We have often noticed stamens which become petals in garden plants too richly fed; well, in certain kinds of orange the stamens show a tendency to turn into *pistil leaves*. First of all, some wrong-headed stamens crop up in quite the wrong place, *i.e.*, much nearer the pistil than the circle of well-behaved ordinary stamens. These extra stamens do not all behave in quite the same way. Some grow stumpily out of the seed case; others reach up till they lay their heads against the very tip of the pistil. Others, again, do not hold on by their head only, or by their stalk only, but by their whole length to the pistil. Thus they absorb, not only nourishment, but character from it; they become like its leaves in colour and in shape. Even the outer ordinary stamens seem sometimes to catch the contagion. They become very fleshy, and the bottom of the stalk turns into a folded blade, which however contains no seeds. The seeds of the true original pistil do not develop either—strength has departed elsewhere, and the stamens are dustless. Thus the abandonment of duty spreads through the flower, and you may imagine what an oddity is produced in the way of fruit—a truly "monstrous" orange protruding many horns. These are the points of the pistil leaves which have been formed by the extra stamens. The "navel" oranges before us are just a

kindred sort of double orange, only the extra leaves do not stick out so much at the top. *Cf.* the similarly-formed "Turk's cap" tomato. It is often very difficult to believe in the relationships of flower members—they look so entirely different; but when we see the extraordinary things which go on under our eyes in the formation of monstrosities, we can realize more readily what a great apparent change may be produced by simple transitions, or unions of one form to another.

**Double oranges.**

Another kind of orange is furrowed like a rough tomato. (Compare the slight waves on a ripe poppy head.) Twenty dents stop just short of a summit which is occupied by horns, not unlike those of the last monstrosity described. But this time the extra pistil leaves have not been formed from stamens, and we must refer to double pears and apples for hints at explanation. You remember that in these the stem does not stop with the birth of pistil leaves, but goes on growing, and produces a second circle—another pear, in fact—inside the first. In some cases the stem is not long enough to keep the two fruits separate: the upper is more or less swallowed by the lower. (See lesson on Apple Fruit.) Finally we learnt about an apple in which only a slight waist in the rather long fruit hinted at a double set of pistil leaves within. If all these previously-studied marvels be borne in mind, perhaps there may be some little chance of the class understanding the structure of one of these monstrous oranges when we cut it across. Behold an outer circle of twenty regular cells (corresponding to the external elevations) which contain instead of pips—is it possible?—miniature oranges! Wonder of wonders! Cut them open, and make sure that they are indeed just like ordinary oranges, but wee enough for fairy food. The middle of the fruit, usually occupied by the thick white column, is extremely large, and contains a number of irregular, juicy, seedless cells. But in the very centre of all are two or three containing some more miniature oranges! These middle cells are, of course, formed by the pistil leaves which project like horns. As in double pears and apples, they are put out by the stem of the fruit, which does not cease growing with the production of the twenty ordinary

pistil leaves. Perhaps, if the children are reminded of the rose which grew buds (or miniature roses), in the joints of petals, stamens, and pistil leaves, they will suggest the truth for themselves: namely, that the two luxuriant pistil leaves of the orange, instead of folding to hold seeds, produced buds in their joints like ordinary foliage; and these buds are represented in the ripe fruit by tiny oranges. The stem of this extraordinary monstrosity finally stopped growing when it produced the final budded leaves which stand out as horns.

**Summary.**—Orange monstrosities demonstrate the kinship of floral members. Stamens may become not only petals, but pistil leaves, which sometimes protrude, horn-like, from the top of the fruit, as do also the extra pistil leaves of double oranges. They produce buds in their joints, which later cause the strange occurrence of fruit within the fruit.

**Art.**—Diaper design of fruits.

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The seventy-fourth and last hour of study should be given up to a prize competition such as terminated the first year.

Each child might, for instance, write an essay embodying whatever facts have most excited his imagination concerning a plant's life.

Or he might try to express any problems which his studies have suggested, and to which he would like to find answers in after life.

# CONCLUDING OBSERVATIONS TO THE TEACHER OUT OF DOORS.

"All the procession of living and growing things passes. The grass stands up taller and still taller, the sheaths open, and the stalk arises, the pollen clings till the breeze sweeps it. The bees rush past and the resolute wasps; the bumble bees whose weight swings them along. About the oaks and maples the brown chafers swarm; and the fern owls at dusk, and the blackbirds and jays by day, cannot reduce their legions while they last. Yellow butterflies and white, broad red admirals, and sweet blues; think of the kingdom of flowers which is theirs! Heavy moths buzzing at the edge of the copse; green and red and gold flies: gnats, like smoke, around the tree-tops; midges so thick over the brook as if you could haul a netful; tiny leaping creatures in the grass; bronze beetles across the path; blue dragon flies pondering on cool leaves of water-plantain. Blue jays flitting, a magpie drooping across from elm to elm; young rooks that have escaped the hostile shot blundering up into the branches; missel thrushes leading their fledglings, already strong on the wing, from field to field. An egg here on the sward dropped by a starling; a red lady-bird creeping, tortoise-like, up a green fern frond. Finches undulating through the air, shooting themselves with closed wings, and linnets happy with their young." *

The foregoing lessons of almost pure analysis ought to be supplemented by visions—not necessarily by rambles. If children *could* sit down quite still (!) around their teacher in the long summer grass of some quiet nook, yet would "all the procession of living and growing things" as it "passes," so well described by Richard Jefferies in the quotation given at the head of this page,* furnish material, not only for much unconscious recapitulation, but for those fundamental conceptions which only come home through the evidence of details innumerable.

We need not fear to nauseate with details so long as they are of interest in themselves: they are the food of imagination. On the other hand, children are naturally speculative

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* Quotation from Jefferies' "Pageant of Summer" which may well be read before we start out. ("The Life of the Fields," Chatto and Windus.)

—they do not stop at the fact itself, but are always ready with a "why?" The teacher should group the details so that they may point to something beyond themselves, and thus lead the child unconsciously to answer its own perhaps unexpressed questioning.

To make him more conscious of the movement around him than of his own movement: this is to bring him out of himself and to place him in relation with the world he lives in.

Original thought—a synthesis not *taught* but *achieved*—is incompatible with tired legs.

But granted that the legs are *not* tired, what then? Do not look for ideas *in* the moment—they are only forming, and if they do not find expression till manhood, still they are forming. Do not hurry Nature's process; be content to direct the lens—the picture will depend on the turn of your hand.*

We have sounded a note of warning, and recommended a general watchfulness on the part of pupils out of doors. Having done this, let us attempt to describe how the teacher's mind may be equipped, through these particular lessons, for rambles with the children.

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* To what extent this photographic instinct may exist ready-made, is evidenced by the following naïve extracts—the first from the letter of a boy just turned fourteen; the second from the diary of his sister, just turned thirteen.

"The other day I went such a nice walk with D., I looked for the plant" (you mentioned) "in the lane, and I found a green one partly out, which D. called Dog's Mercury. Is that it? I found the wood anemone out there, and a lot of stitchwort (?) in the lane beyond. Is it a white flower with very slender trailing roots with four petals split into two? Then we went on to Wild Duck Pond, where I saw a lot of young tadpoles, and got a nice beetle. We then went on, picking a lot of may flowers in the marsh; we saw a pair of marsh tits, probably building there. In peering into the mere I found three more kinds of caddisworms. I now can enumerate seven kinds as found about here. Almost as soon as I got through the gate I saw a butterfly, new to me in this district, though I think it is the same as one I have caught at . . . . I think it is the grizzled skipper, but I will make certain in the museum to-morrow. I did not catch it, however. Going up to the top of the hill we saw what we think was the great black and white woodpecker, operating on the bough of a tree very high up. As we crossed the top of the mound and got to its edge by the underwood, a fox passed us at a *slow* gallop, about three yards in front of us—a fierce-looking grey old beggar. It did not pay any attention to us, though we could almost have touched it with

Supposing we walk through only half a mile of country, and that we try to count all the flowers on the way, how soon do we give it up! And how much sooner should we be tired if we were to try and remember their shapes,—no two are alike. Yet perhaps it has occurred to us during these lessons that the great melon flower and the starry little crossworts, the scaly corn bloom, gorgeous tulips and poppies, sweet fruit blossom and sweeter roses, the buttercups, the columbines, the larkspurs, all, however diverse, may not only sometimes be unexpectedly akin amongst themselves (like the last three mentioned) but have always a kindred structure, traceable even where least developed (18) or most abandoned (57, 61).

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a stick, about double the length of an ordinary walking stick, probably because we were quite still."

From "D.'s" diary:—

"This afternoon as I was getting leaves for our collections under the trees in front of the house, I heard a great splashing in the pond. I quickly crept down the bank and crouched under the elderberry bushes. There I saw a female wild duck being chased by some water-hens. Just as I came up, however, they left off and I do not think they saw me. Presently the wild duck flew away, and I took to watching some little water-hens in different stages who were swimming about in the water. Some of them came up quite close to me, and as I had a pencil and paper in my pocket, I took to drawing them. One or two of them were so tiny that I think they could not have been very long hatched, others were evidently older, but all, I think, were covered with black down. As I was watching them I heard a bird making a sort of scolding noise near me, and I saw it was a fly-catcher; at that moment a squirrel came hopping down from the tree and ran past me within a yard, I should think. The next day I found the fly-catcher's nest with five eggs in that tree! Presently the old water-hen came back, and behaving much in the manner of a hen with chickens, clucked the young ones away under the elderberry bushes beyond me, and I saw no more of them, though I could still hear them. The young ones made a sort of piping noise very like small chickens. As I was drawing the railing that runs out into the water, I suddenly looked up and saw a bird sitting on it. The next moment it popped down to the water, into which it plunged its beak and up again in a minute, and I saw it was a kingfisher. I watched it, and another that joined it, for about ten minutes I should think, before it flew away to another part of the pond, where I could see them very well through G.'s telescope. They probably had a nest somewhere near, though I could not find it, and father says they used to build there in old days. I think they must have been feeding on beetles and leeches, as . . . says they feed principally on that besides small fish, stickle bats, minnows, etc., which are not found in the pond."

Petal circlet within sepal circlet—stamens within petals—crown within crown, each blossom rears its head; so much more regal is the continual pageant of our fields than even the most gorgeous coronation ceremony: the tiniest weed may enthrone some trebly-crowned flower-king. (7. *2nd and 3rd Section.* 9. *1st Section.*)

Crowns, not of dead gold, but of living matter. Each part of every crown full of busy cells. (34. *4th Section.* 12. *4th Section.*) And this brings us to what each part really *is*—just the thin membrane of vegetable substance which we call a "leaf"! (53.)

Not only can most of us only think of one thing at a time, but we can only apply our idea in a single way; or at most, in a very few ways. Here is an idea of Nature's: the idea of a leaf, and the human mind cannot contain all the applications of it.

We have heard of round people unable to fit into square holes, but this little leaf adapts itself to all circumstances—dresses itself to suit any kind of work—shapes and fits itself to its standing—the place allotted to it on the tiny stage or platform of the flower. And if it is a green leaf which is no part of the flower, and which looks more or less like itself, still it preserves the same willingness to serve the plant as a whole.

"I will do such and such work" we hear some people say; "but I will not dress as if I did it."

Some doughty plants there are who will stand no such nonsense, and who simply execute their mutineers. (21.)

But what happens to a plant who tolerates mutiny? It simply ends by dying out, unless indeed a gardener comes to the rescue. (Broadly speaking, double flowers, for instance, are maintained by gardeners through those portions of the plant which are not on mutiny; and when the gardener's care is withdrawn, they revert to the single type.)

To particularize:

How have we seen the well-behaved leaf dress, and what have we seen it do?

Dressed properly and in its own character, it imprisons sunlight and feeds the plant (12); but of this, its chief function, we must learn in the "Wonderland of Science."*

*Arabella Buckley's "Life of a Primrose." In this book is an excellent introduction to physiology.

We know that sometimes the leaf helps to take care of the young central shoots of the plants (31, *S*.2.), and we may add that sometimes it has hard enough work to take care of its poor little self. (This is why young thistles and groundsel put on woollen overcoats in early spring and late autumn; summer seedlings are much smoother.)

The first two leaves of a plant have a quite unique function—they feed the succeeding growth (41) as do also the underground leaves of a bulb (11).

The first time the leaf looks most unlike itself is when it appears in a shiny brown waterproof, again taking care of something—the young buds of Spring! (1, 47, etc.) We find it doing the same duty, only in greener garb, as a stipule (47, *S*. 2) and the currant bushes let out the secret of its real nature. (*Sections* 5 *and* 6.)

The sepal is sometimes not unlike the stipule in dress and duty: it is one of the flower's outermost guardians; the petal of the next circlet is also sometimes very like the preceding, but more generally its duties are so special that it requires a very special outfit of gorgeous hues, and sometimes, also, of very strange shapes. (21, 25, 43, 46, 48, 52, 55, 57, 60, 61, 62.)

The more gorgeous the hue and the stranger the shape, the more safely may we surmise that the special duty has relation with the insect world: when the sepals and petals are insignificant, light, easily swayed—we think of the wind and of all we saw in the cornfield on a summer morning. (18.)

It is when we approach the centre of our flower that we find the greatest difficulty in realizing that our leaf is but disguised. Tulips (9, *last Section*), strange fruit blossoms (46, *S*. 4, 53, *S*. 3), and garden roses (56, *S*. 3), all help to tell the tale with regard to the stamens. But how seldom do we find a pistil that in the least reminds us of a crown of leaves! If it were not for extraordinary strawberry blossom (53, *Section* 4)—roses (56, *last Section*)—columbines (58, *S*. 4, *and last Section*), should we ever believe at all in so complete a transformation? The special duty—the most special of all, and the "roof of things" indeed, though seldom the "crown," involves the completest surrender of all those beautiful things which a real leaf may be. No longer bright,

transparent, green and shapely, it is the sombre, stiff and crumpled guardian of those little seeds which shall one day give verdure to our world.

But in the case of ripe fruit, even this sombre guardian is sometimes able to put on a gay dress coat,—perhaps the gayest of all—when the seeds are ripe and the flush of achievement sets in. (48, *last Section.*)

At last there is the perfected seed itself to consider, the object of all foregoing solicitudes—and, marvel of marvels! again we find the all-adaptable idea—a leaf which folds (58, *Section* 4) to hold a bud! (36, *2nd Section.*)

Now have we briefly reviewed gradations of task all leading up to and centering in the well-being of the race—it only remains to remember how rudely man breaks in on this wonderful order and causes one member to swell proudly at the expense of another, causing rankness and luxuriance where there should be restraint and subordination. (21, 25, 26, 27, 28, 30, 34, 67, 72.)*

Do we at last clearly apprehend to what a colony of mutual helpers we refer when we talk of a plant? If we substitute the word "organization" for the word "organism," it will be clear to us that we have to do, not with one thing, but with many members; each dedicated to the welfare of the whole, and having its special work to do.

If we further consider that the entire world, of which our plant is but a member, is itself an infinitely more vast and complex organization, and that the plant as a whole plays its own subordinated part therein—then we may begin to realize faintly what "wonder" (often lightly felt for foolish causes) really means. And this wonder will grow and grow upon us as our knowledge grows. Now we begin to see, but in a glass darkly, how soil and shelter, sun and wind, affect our plant and how in its turn it ministers to beast and man. But not until we take the microscope in hand, and further, not until we learn of those powers which no microscope even can body forth to us—of the spirits of earth, and air, and water—may we

---

* The anchoring root and supporting stem (11, 13, 64, 65, 66) are omitted from this summary for the sake of the particular train of thought emphasized.

so much as imagine how dead things beget life, and how the higher life cannot live without the lower.

> Birth and the grave,
> An infinite ocean,
> A web ever growing,
> A life ever glowing.
> Thus at Time's whizzing loom I ply,
> And weave the vesture of God, that thou know'st Him by!

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| 2. Oats. | 6. Buckwheat. | 10. Turnip. | 14. Millet. |
| 3. Barley. | 7. Bean. | 11. Potato. | 15. Onion. |
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16. **Illustration of the Dispersion of Seeds.**—Balsam, Dandelion, Elm, Goose Grass, Egyptian Bean.
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5. **Eagle.**—Head, Beak, Talons.
6. **Slug.**—Shell, Eggs.
7. **Spider.**
8. **Fly.**
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10. **Bee.**
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Plate 1. **Development of a Dicotyledonous Plant (the Bean)—**
1 and 2, Entire Seed. 3, Ditto, Seed Cover removed. 4, One Cotyledon separated to show Position and Form of Embryo. 5, The Young Plant with its first Green Leaves.

„ 2. **Development of a Gymnospermous Monocotyledonous Plant—**
1, Seed of Wheat Longitudinally with Embryonic Plant. 2, Ditto, after Embryonic Growth, with first rootlets and leaves. 3, Scale of a Fir Cone from within, showing the the two winged seeds. 4, Ditto, from without. 5, Seed with Embryo, longitudinally seen in section. 6, Young Seedling with Seed Leaves.

„ 3. **Development of Cryptogam (Parmelia parietina)—**
1, Position in transverse section of the basin-formed Fruit, enlarged 250 diameters. 2, Spore-Case with eight spores enlarged 5,000 diameters. 3 and 4, A two-celled Spore from either side enlarged 12,000 diameters. 5, The same Sprouting.

„ 4. **Root Forms—**
1, Tuberous Root, Secondary Roots of Grasses and most Monocotyledons. 2, Branched Main Root, Tap Root of a Dicotyledon. 3, Thickened Tuberous Roots of Dahlias.

„ 5. **Stem Forms—**
1, Blades of Grasses. 2, Onion from without. 3, Ditto, longitudinal section. 4, Tubers of Potato. 5, Rhizome of Convellaria.

„ 6. **Buds—**
1, Pedunculate Oak (Quercus pedunculata). 2, Pear (Pyrus communis), with Fruit and Wood Buds. 3, Transverse section of Oak Buds. 4, Fruit Bud of Pine (Abies), longitudinal. 5, Two Flower Buds of Syringa (Lilac), longitudinal.

„ 7. **Leaf Forms—**
1, Long Serrated Leaf. 2, Ovate Toothed Leaf. 3, Round Entire Leaf. 4, Cordate and Notched Leaf. 5, Arrow-shaped Leaf. 6, Peltate Leaf.

„ 8. **Leaf Forms—***continued.*
1, Lobed. 2, Divided. 3, Cut. 4, Compound Leaf.

„ 9. **Leaf Insertion—**
1, One-eighth Alternate. 2, Two-fifths Alternate. 3, Opposite and Alternate (Cross). 4, Whorled. 5, Rosette of Leaves, three-eighths position.

„ 10. **Stamens—**
1, Stamens with Filament and Double Pollen Cases. 2, Larger and in transverse section. 3, Pollen Case set obliquely on the Filament (Grasses). 4 and 5, Forms of Pollen Grains. 6, Such a Pullen Grain with Tube developed.

„ 11. **Pistils—**
1 and 2, Pistil with one-celled Carpel, Style and Stigma. 3, Two-celled Carpel with Sessile Stigma. 4, Three-celled Carpel. 5, Pistil with Lateral Stigma. 6, Pistil with Plumose Stigma.

„ 12. **Forms of Corolla—**
1, Tubular Flower of Tobacco. 2, Radiate Flower of Potato. 3, Bell-shaped Flower of Campanula. 4, Funnel-shaped Flower of Convolvulus. 5, Tongued-formed Flowers (Ligulate). 6, Lipped Flower of Sage. 7, Scrophulate Flower of Linaria. 8, Papilioneous Flower of Pea.

„ 13. **Flower Aggregation—**
1, Compound Ear of Wheat. 2, Catkin of Fir. 3, Berry of Juniper. 4, In Longtudinal section.

„ 14. 1, Simple Umbel of a Cherry. 2, Compound Umbel. 3, Corymb. 4, Head or Caput of Flowers.

„ 15. **Fruits—**
1, Berry of Grape, longitudinal section. 2, Stone Fruit of Cherry, longitudinal. 3, Fruit and Wild Clematis. 4, Winged Fruit of Elm. 5, Double-cased Fruit of the Hemlock. 6, Three-partite Capsule of Meadow Saffron (Colchicum). 7, Ditto in section. 8. Pod of Pea. 9, Siliqua of Rape. 10, Compound Fruit of Blackberry. 11, Ditto, in section. 12, Single Seed from the same, longitudinal. 13, Apparent Fruit of Strawberry.

Plate 16. **Characteristics of some Natural Plant Families—**
1. Papilionaceae (Beans). 2, Stone Fruit (Cherry), superior fruit. 3, Pomacene (Apple), inferior fruit. 4, Cruciferae (Rape). 5, Umbelliferae (Hemlock).

,, 17. **Characteristics—*con.***
1, Nightshade Family. 2, Labiate (Thyme). 3, Capitate, single ligulate flowers (Arnica montana). 4, In longitudinal section. 5, The Anthers dissected.

,, 18. **Characteristics—*con.***
1, Catkin-bearers, Female Flower of Oak (Q. pedunculata). 2, Part of a Male Catkin of the same. 3, Fruit of same. 4, Orchideae (O. Militaris). 5, Gramineae (Flower of Wheat).

,, 19. **Characteristics—*con.***
1, Coniferae, Male Flowers of Fir. 2, Young Cone, Pistilliferous Flowers of the same. 3, Single Scale of the Cone with two seeds at base. 4, Fern, Leaflet Form (Aspidium Filix Mas). 5, The Male Fern with Sori in transverse section. 6, Single Spore Case from the above.

,, 20. **Characteristics—*con.***
1, Muscae, entire plant of Funaria hygrometrica enlarged 25 diameters. 2, The Cap of the Spore Case. 3, Single Spores enlarged 3,000 diameters. 4, Algae, end of Thread of Spirogyra, or Fresh Water Algae. 5 to 14, Fungi. Potato Disease (Peronospora infestans). 15, Developed Plant with three Spore Heads enlarged 2,000 diameters. 6, Single Spore Head enlarged 4,000 diameters. 7, Escape of the Spores from their surrounding envelope. 8 and 9, Single Spores with two Cilia. 10 to 14, Development of the Young Growth from the Spore.

,, 21. **Plant Cells—*con.***
1, Nucleated Cells enlarged 3,000 diameters. 2, Long Porous Wood Cells. 3, The same, cross section, enlarged 3,000 diameters. 4, Mono-cellous Algae (Micrasterias crux melitensis), enlarged 2,000 diameters.

,, 22. **Textile Threads, enlarged 2,000 diameters—**
1, Cotton. 2, Linen. 3, Silk. 4, Wool.

,, 23. **Cell Division.**

,, 24. **Cellular Tissue—**
1, Pith, Parenchyma with Intercellular passages. 2, Asteriod Cell Tissues, with large inter-cellular passages from the rush, enlarged 2,000 diameters.

,, 25. **Thickening of Cell Walls—**
1, Transverse section of so-called "gritty" pear, porous cellular tissue (i.e., part changed to wood), enlarged 2,000 diameters. 2, Schematic representation of the thickening of non-porous cell-walls. 3, Ditto, with pores.

,, 26. **Thickening of the Cell Wall—**
1 Dotted Cells of Fir. 2, Single Dotted Cell in section enlarged 4,000 diameters (from a Pumpkin). 4, Spiral Vessels enlarged 4,000 diameters. 5. Ringed Vessels enlarged 4,000 diameters.

,, 27. **Starch—**
1, Of Wheat. 2, Oats. 3, Peas. 4, Potato enlarged 5,000 diameters.

,, 28. **Vessels—**
1 and 2, Porous Dotted. 3, Spiral. 4, Ringed. 5, Reticulated. 6, Stop-shaped Tissue enlarged 2,000 diameters.

,, 29. **Construction of a Woody Stem. Schematic View—**

,, 30 and 31. (Double plate.) Construction of a Dicotyledonous Stem. Section of Tobacco Stem. A, Epidermis. B, Bark. C, Bast. D, Sap (Cambium) Layer. E, Wood (Wood Cells and Vessels). G, With Radial Pith Layers. F, Pith enlarged 1,000 diameters.

,, 33 and 34. (Double Plate.) **The same seen longitudinally—**

,, 34. **Annual Rings.** Section (radially and tangentially longitudinal), of Fir Wood, with boundary between the annual rings enlarged 1,200 diameters.

,, 35. **Stomata of Leaves—**
1, Single Pink Leaf. 2, Of Elder enlarged 2,500 diameters.

,, 36. The same in section, enlarged 2,500 diameters.

,, 37. **Construction of a Leaf (Ivy in Section).**
A, Epidermis of the superior side. B, Thickly-set Cells with Chlorophyll. C, Cells with Crystal. D, A Leaf Vein. E, Epidermis of Lower Side with Stoma. G, The Stoma itself enlarged 2,400 diameters.

,, 38. **Forms of Hairs—**
1, Mona-Cellular Hair. 2, Poly-Cellular Hair. 3, Branched Hair. 4, Scaly Hair (Elegans). 5, Glandular Hair. 6. Nettle Hair (Stinging).

,, 39. **Reproduction of Plants—**
1 and 2, Grafting. A, Bud. B, The same Budded into the Wild Stock. 3 to 5, Budding. A, Slips with Bud. B, With T-shaped Cut. B, The Bud fixed into the Stock.

| | | |
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| 39 Plates, size 25 by 34 inches, in sheets, unmounted .. .. .. .. .. .. | net £1 | 18 0 |
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431. The Series will consist of Twelve Plates depicting the animals most useful to man; the characteristic features of form and structure which are closely related to the mode of life of the animals are fully dealt with and are available for comparison between one animal and another. The illustrations are life-like, and are printed in chromo colours and measure in size 29 in. by 40 in.

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| | | |
|---|---|---|
| Green Woodpecker | Marsh Titmouse | Greenfinch |
| Chaffinch (Male) | House Sparrow (Male) | Skylark |
| Chaffinch (Female) | Starling | Meadow Pipit |
| Whitethroat | Great Titmouse | Blackcap |

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